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Global Crisis Atlas: Mapping for situational awareness

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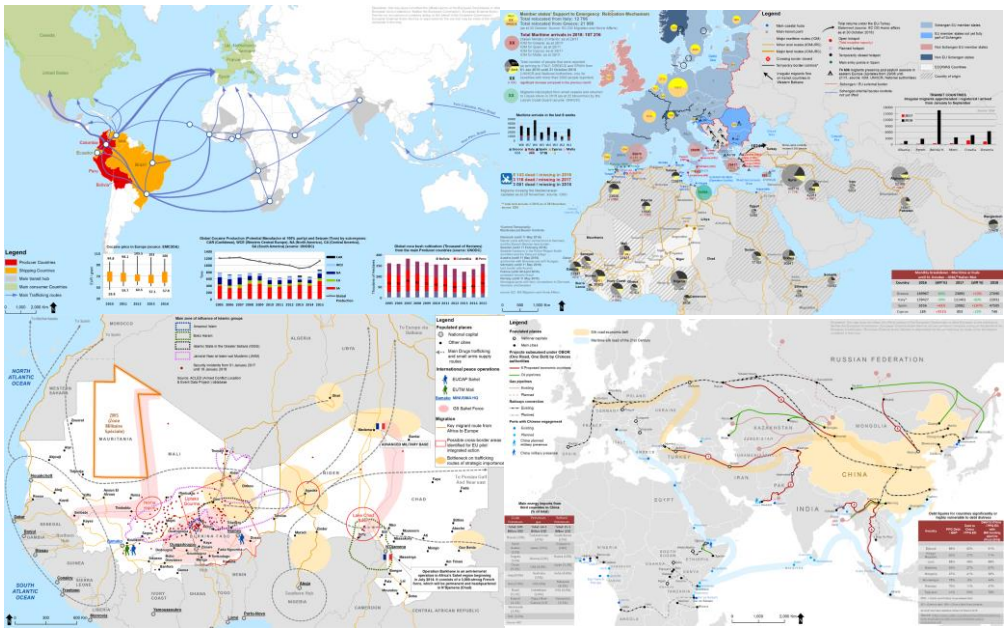

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Foreword

Maps are powerful yet simple tools to visualise information. Nowadays the interpretation of the information is getting more difficult due to the multidimensional and multilevel nature of the reference contexts and the vast availability of unstructured data. Mapping tools allow reducing the complexity of the information and deriving knowledge that can be used to inform decisions and policies.

In this technical report, we present the Global Crisis Atlas (GCA), a catalogue of digital maps produced by the JRC analysts of the Peace and Stability team (JRC E.1 Disaster Risk Management Unit) to meet the intelligence requirements of the External Action Service of the European Union (EEAS) and the Foreign Policy Instrument (FPI). The GCA maps are intended to support the work of EEAS and FPI by raising situational awareness about critical or potentially critical events, namely the understanding of the elements, events and actors influencing the unfolding of a situation at a given time. This is achieved through a combination of geospatial (GEOINT) and open source intelligence (OSINT) and the incorporation of vector data, graphs and diagrams. The knowledge synthesized in the maps is harvested using wide-ranging sources as shown in the figure 1 below.

Figure 1: From diverse information streams to a structured GCA map

The GCA maps can be accessed by the means of a web interface. Given the sensitivity of the information displayed on the maps, access is subject to authorisation credentials.

Who should read this report?

This report is intended to reach out to technical experts working on crisis and conflict prevention and management within and outside EU institutions in a research or

operational capacity. This includes existing and potential users of Global Crisis Atlas as, for example:

- EEAS and FPI
- European Commission services and DGs
- Other EU affiliated institutions
- Non-governmental organisations supporting peace and stability actions
- International organisations (World Bank, UN etc.)
- Research centres

What is this report made for?

The objective of this report is twofold:

1. Systematically introduce the GCA service's features and functionalities to our existing and potential users.

2. Set out the path for an improved GCA product and service, which brings together better usability and visualisation functions with an innovative approach to conflict and crisis prevention and management.

We aim to improve our GCA product and service delivery, in order to integrate crisis mapping in the conflict risk prevention toolbox (e.g. Halkia et al., 2017), beyond the situation awareness context in which it is currently used, but also to enable policy makers to access the information about the wider context of a situation in which they are operating. For this we propose a vision which allows for both defining the intended ultimate objective of our effort and the steps to reach it. The process we adopt is depicted in figure 2.

The first step is *reframing* our work within the theoretical framework of crisis and conflict mapping. This includes acknowledging previous scientific research as well projects implemented in the field. GCA already capitalises on the information furnished by other mapping services to collect insights and populate the situation maps. This first step enables to strengthen further the links between our work and previous work conducted in this field.

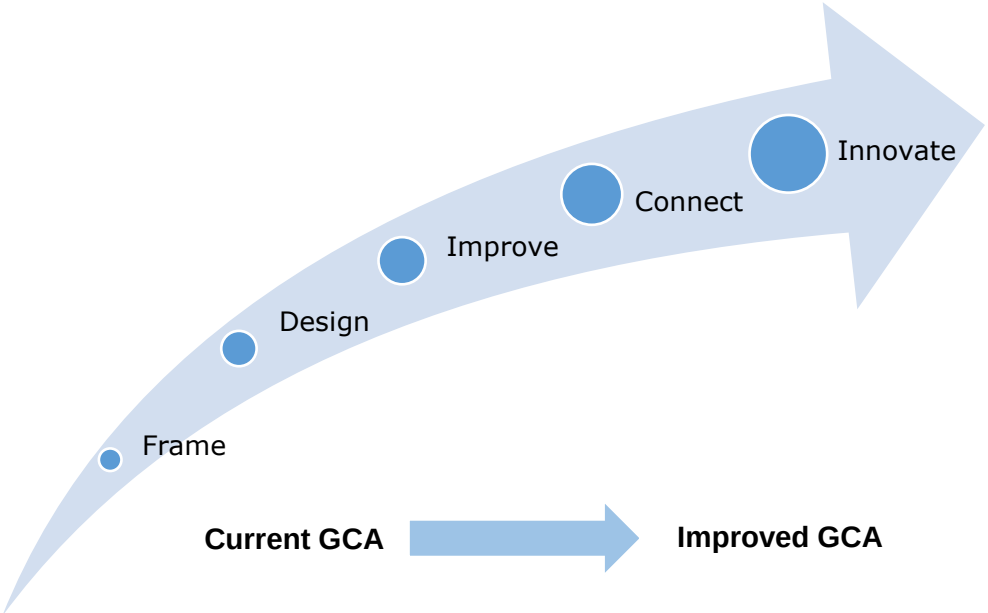

Figure 2: Path and steps from current to improved GCA service and product

Within this larger framework, we *place and design* the GCA service and product. At the moment, GCA factors in several functionalities that enable the user to visualise the information of interest and come up with an improved understanding of a critical situation or of the elements that might trigger a crisis or conflict. These functionalities are extensively described in chapter 2.

The third step involves the *improvement* of service delivery by the development of new functionalities and features. This includes, for example, integrating the GCA maps into a bigger and more dynamic interface.

The final steps allow to find synergies between the various streams and pieces of our and others' work, *connect* them in a meaningful way and generate an *innovative approach* to conflict management.

Contents of the report

The content of this report reflects the steps just described.

In the first chapter of the report, we place the GCA work within the general theoretical framework of crisis and conflict mapping, which has gained ground in the last decade. This field has largely tapped into the ability of the public to produce and disseminate information to pull in the wisdom relevant for the understanding of a crisis, disaster or conflict. A list of common features is developed from the analysis of some crisis and conflict mapping tools.

In the second chapter, we illustrate the instrument of Global Crisis Atlas. We highlight the procedure for data collection (including a table with data sources), processing and analysis. In that, we inform on how the data are elaborated to generate valuable information and then injected into the maps. We then describe the procedure for production and dissemination of the maps. At the end of the chapter, we present a table, detailing the features of the GCA tool and the extent to which they match those identified in other crisis and conflict mapping tools and highlighted in chapter 1.

Chapter 3 is dedicated to showing the continuous effort made by the GCA analysts to render the maps more usable, comprehensible and accessible. Intelligence requirements are growing in complexity and so are the maps that need to be produced in order to accommodate them. With this in mind, GCA analysts come up regularly with improvements that enable to expand or potentiate the functionalities and contents of the GCA service and maps.

Chapter 4 sets out the directions and priorities for future work. Interactive prototypes to improve the GCA service are still under development. However, what has characterised the GCA as a tool underpinned with scientific and technical rigour that has the ability to support European policymakers in their critical decisions will remain the guiding principle in the next phases of its deployment and service to the Instrument for Stability and Peace.

Acknowledgements

We would like to acknowledge the contribution of Federico Zorzan (EEAS), Marc Fiedrich, Santiago Robles, and Sebastien Babaux (FPI) to the development of the Global Crisis Atlas.

Abstract

It is commonly accepted that crises and conflicts have an inherent geographical nature in that they are embedded in, and eventually shape, the contexts where they take place. In this view, it becomes critical to understand contextual and relational dynamics that drive the unfolding of events and the actions of key actors within a crisis or conflict. Maps offer an effective and handy support for displaying crisis and conflict-related data and visualising contextual and relational dynamics. In the maps, the geographical coordinates of people and events are portrayed in such a way as to highlight causal relationships, areas of influence and power structures. Moreover, the advent and rapid spreading of geographical information system (GIS) has greatly improved the usability of geographical data for understanding conflict and crisis dynamics. Indeed digital maps are more easily editable than print maps and allow for adding new information layers as the complexity of the situational determinants become clearer.

This report is produced by the Peace & Stability team of the Joint Research Centre, which seats under the umbrella of the Disaster Risk Management Unit (E1) – Directorate Space, Security and Migration. The team deals with projects related to the understanding of crisis and conflict risk dynamics. The ultimate objective is the enhancement of situational awareness and the support to decision-making processes of EU policymakers during critical or potentially critical situations. *Global Crisis Atlas (GCA)* is one of the work packages of the Peace & Stability team. It consists of a repository of digital maps, accessible by the means of a web interface, that furnish an overview of the elements that influence (or might influence) the rise or unfolding of crises and conflicts. GCA maps are produced to respond to the intelligence requirements of the European External Action Service and to complement the information already provided by its intelligence centre (INTCEN - EU Intelligence and Situation Centre).

The current report is divided into four chapters. The first two chapters serve as presentation of the GCA theoretical framework (chapter 1) and of the tool's features and functionalities (chapter 2). The last two chapters highlight future developments in terms of new functionalities implemented as well as innovative approaches to the understanding of crises and conflicts that the GCA tool may enable. The arguments brought forward in each chapter are enriched with the support of reading boxes, figures, diagrams and tables.

In the conclusions section, we illustrate how the work of the Peace & Stability Team fits within the general objectives and values of the JRC Strategy 2030. In doing so, we highlight that, despite the independent work packages of each directorate, the Joint Research Centre should be conceived as a unique entity whose scope is to help EU policymakers in the design, implementation and review of critical decisions and to better the functionality and resilience of the EU societies.

1. Crisis and conflict mapping

Policymakers need data on the trends associated with security events, a precise spatial location, and details of events in order to monitor and analyse the situation properly (Mubareka et al. 2005).

*Spatial analysis can provide new and important insights into the dynamics of conflict and processes of peace as situated within and constitutive of different spaces and agencies (*Björkdahl and Buckley-Ziste, 2016, p.1)

As today's societies are growing in complexity and rapidly evolving so are the dynamics of crises and conflicts. Adding to this, the advent and wide distribution of information and communication technologies and mobile devices have made a tremendous amount of data available to everyone with an Internet connection. As a result, policy makers are in need for new instruments to navigate the big data universe, grasp new societal patterns and eventually take informed decisions that can lead to effective policies.

Maps are acknowledged as a powerful tool to visualise data. Two features contribute to this. On the one hand, maps allow to view on a single page spatial dependencies and relationships between people, assets and events. This approach recognises the inherently geographical nature of social events that are embedded in, and eventually shape, societal contexts and landscapes. On the other hand, interactive maps show visually the temporal evolution of social events, thus revealing patterns and trends that remain concealed to a merely narrative analysis. For this reason, they have been used in a plethora of projects to make predictions about social phenomena.

- **Visual support**: It can be used to sustain a written analysis as well as an oral presentation.
- **Accessibilit**y: It is easily accessible and therefore useful for a very diverse audience. Examples of interested groups are: international workers, the press, policy makers and the general public.
- **Interaction:** The analysis gives occasion for interaction since readers or audiences have access to the sources (the maps) it is based on.
- **Objectivity**: Because the sources are shared with the interested public, there is an extra guarantee for objectivity.
- **Open to new developments:** New information or developments can easily be added to previous findings. All it takes is one new map to be compared with the originals.
- **Reveal drivers, motivations, parallels etc.** Applying the tool will shed a new light on the interaction of different war motivations because it will reveal contradictions, parallels etc. In some cases, it might reveal intentions or drivers which were previously hidden behind the discourse of warring parties.

Spittaels and Hilgert (2011, p. 30)

Box 1: Advantages of Using Mapping to visualise Crisis- and Conflict-Related Data

As an example, the World Health Organisation (WHO) has produced maps to visualise the outbreak and spreading of Ebola virus in Western Africa countries. These maps, along with other forms of information, have then contributed to inform and guide the actions and decisions of WHO on when, how and where allocate resources to respond to the health crisis.

Crisis Mapping as a field emerged in 2007 by the initiative of the Harvard Humanitarian Institute. Its primary scope is harnessing mobile technologies, spatial data and citizens reporting to support interventions during humanitarian crises and disaster response (Stottlemyre and Stottlemyre, 2013).

The devastating earthquake that hit Haiti in 2010 gave a spur to this field, with lay citizens and emergency organisations starting to use information from social media and other open sources to coordinate relief efforts (Yates and Pasquette, 2011). Collaborative online mapping platforms, such as Ushahidi, greatly contributed to the effort to organise data and translate them into actionable information (Mora, 2011). Notably, while maps of social events were arguably available long before 2007, the development of Geographic Information System (GIS) technologies brought along innovations in terms of availability, usability and production of geographical information. Products like Google Earth allow anyone to access geographical information and to use it to derive insights. Moreover online mapping platforms like Openstreetmap allow not only experts trained in geographical methods but also the general public to produce maps by providing an intuitive and user-friendly tool. Finally, the dissemination and sharing of geospatial data is facilitated by web-based applications such as Geonode.

As a matters of facts, the primary scope of every crisis or conflict map is to support the acquisition of **greater situational awareness**, defined as "*the perception of the*

USHAIDI (https://www.ushahidi.com/) Ushahidi, which translates to "testimony" in Swahili, was developed to map reports of violence in Kenya after the post-election violence in 2008. Ushaidi provides a platform for multi-source data extraction, data management and visualisation. During past years, Ushaidi has been deployed for the reporting and monitoring of electoral processes, human right violations and media freedom.

CRISIS MAPPERS (crisismappers.org) Crisis Mappers leverage mobile & web-based applications, participatory maps & crowdsourced event data, aerial & satellite imagery, geospatial platforms, advanced visualization, live simulation, and computational & statistical models to power effective early warning for rapid response to complex humanitarian emergencies. As information scientists, they also attempt to extract meaning from mass volumes of real-time data.

HUMANITARIAN OPENSTREETMAP - HOT (https://www.hotosm.org/): HOT is an international team dedicated to humanitarian action and community development through open mapping. HOT develops open source apps and tools for collaborative mapping and geospatial data collection. The tool is free for all to use and leveraged by partners such as Red Cross societies, Médecins Sans Frontières, UN agencies and programmes, government agencies, and local NGOs and communities. During past years, the HOT community has worked on projects aimed at revolutionise disaster management, reduce risks, and contribute to achievement of the Sustainable Development Goals.

ACLED (www.acleddata.com): The Armed Conflict Location & Event Data Project (ACLED) is a disaggregated conflict collection, analysis and crisis mapping project. ACLED collects the dates, actors, types of violence, locations, and fatalities of all reported political violence and protest events across Africa, South Asia, South East Asia, the Middle East, Europe, and Latin America. Political violence and protest includes events that occur within civil wars and periods of instability, public protest and regime breakdown. ACLED's aim is to capture the forms, actors, dates and locations of political violence and protest as it occurs across states. The ACLED team conducts analysis to describe, explore and test conflict scenarios, and makes both data and analysis open to freely use by the public.

Box 2: Examples of crisis and conflict mapping projects

elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future" (Endsley, 1995). In more operational terms, situational awareness allows one to understand the elements (e.g. participants, assets, goods, relationships etc.) influencing the situation in a given context and time and to build plausible scenarios about how the combination of these elements might evolve in the future. Situational awareness is a core component of every decision making process in that it helps the recognition of a need for information and guide the information acquisition, the weight of alternative decisions and eventually the review of the decision taken. Figure 3 describes the decision making process and its correlation with situational awareness

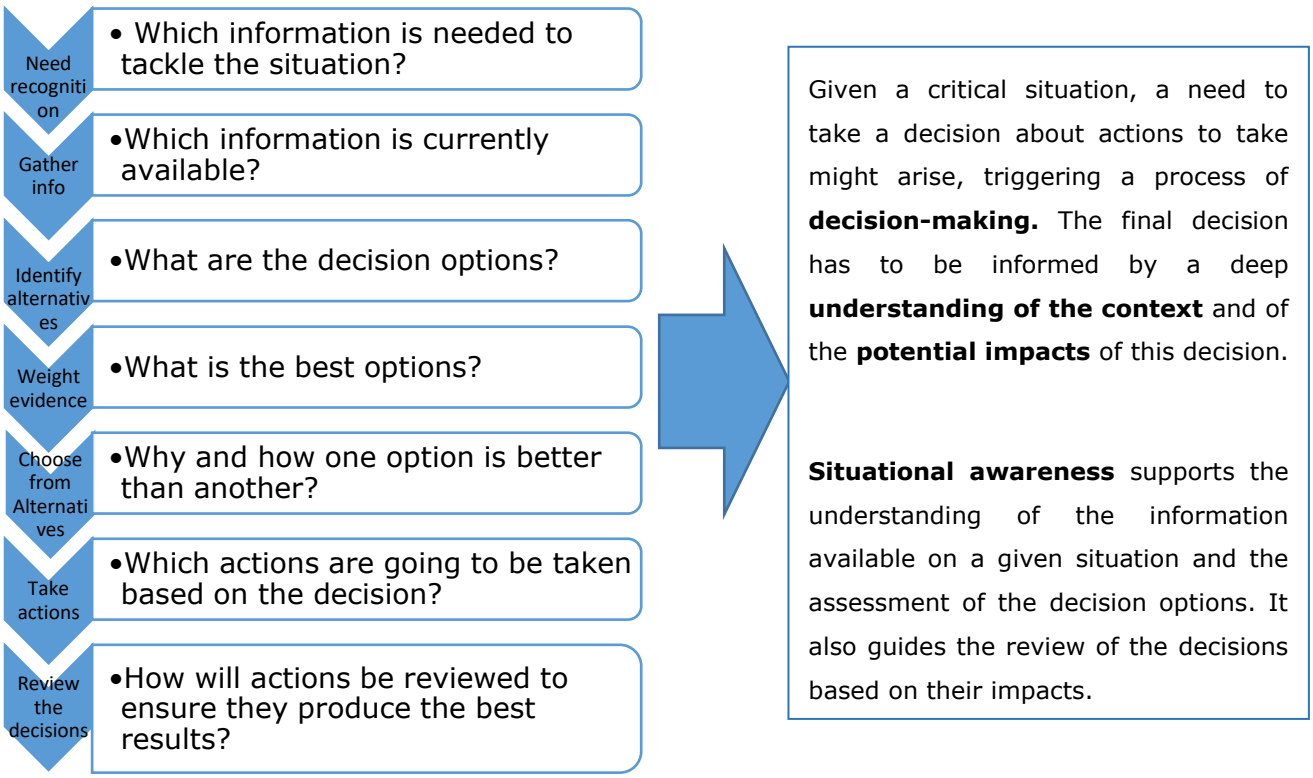

Figure 3: The decision making process and the role of situational awareness

How do maps contribute to situational awareness and in turn to better decision making during crises and conflicts?

1. Maps display the information available, also adding its spatiotemporal coordinates. In doing so, they help to situate the information within a given space and time.
2. Maps reveal patterns and relationships between information, thus unveiling crisis' and conflict's drivers.
3. Maps help to build *what if* scenarios to evaluate alternative options and impacts.
4. Maps make visually evident the impact of the decision on the situation.

1.1. Peculiarities of conflict mapping

Conflict analysis is the systematic study of the profile, causes, actors, and dynamics of conflict. Conflict mapping is a recognised tool for conflict analysis, in that it serves to visualise 1) the actors and their "power", or their influence on the conflict, 2) their

relationship with each other, and 3) the conflict theme or issues (Center for Security Studies, 2005 p. 5). In other terms, it allows to come up with an improved understanding of the drivers and issues in a conflict setting and unveil causal relationships and correlations between events and actors. Findley and Young (2012), for example, used a map to explore the extent to which terrorism and civil war overlapped and was eventually able to prove visually the co-occurrence of these phenomena. Conflict mapping offers a geographical approach to conflict analysis, paying attention to war dynamics as both geographically constituted and geographically expressed (Rech et al. 2015). The spatial representation of conflicts enabled by digital technologies may be a means for negotiating, and eventually settling, international disputes (Branch, 2017). Conflict mapping is used to orientate future actions to address risks associated with the outbreak of new violent crises and it can therefore be considered as a conflict risk prevention and management tool.

While conflict mapping can rationally be included under the crisis mapping umbrella, it is important to highlight some peculiarities that make conflict-related maps somehow different from other crisis maps.

- *Political nature:* The collection, management and visualisation of data is always bound with political considerations that determine which data are collected, how they are presented and to which elements is given more prominence (Boehnert, 2016). This is particularly true for conflict-related data where stressing one component over another can change the perception of the situation and the resultant decisions taken. A conflict map is primary a geopolitical map that shows the dynamics leading to future scenarios and has an interpretative, rather than just descriptive, intent (Boria, 2008). For this reason, when "reading" a conflict map is relevant to question who did the map and what interests and worldviews the map intends to reflect.

- *Data sensitivity*: The deployments of maps in conflict zones is a sensitive matter as data visualised on a map can be easily exploited by armed groups to prepare attacks and other hostile actions (Chamales and Baker, 2011). For this reason, it is critical to gauge accurately who can access the conflict maps and *for what purposes* the data mapped will be used.

- *Data disaggregation.* When studying conflicts, it is important to highlight the local nature of many conflict drivers and dynamics. Data aggregated at country level risks not to capture correlations that become instead evident if looking at the situation in finer details (Rød, 2003). Furthermore, disaggregated data allow adding contextual information to a map that help to clarify causal relationships (Raleigh et al., 2010). In conflict maps, data are usually disaggregated spatially (i.e. showing where a violent event occurs). However, depending on the conflict drivers identified, it might be also useful to disaggregate data by theme (thematic map), for example by visualising the distribution of the ethnic groups within a region.

- *Geographical and abstract components:* Each map has two focuses: one is the geographic space (represented by the map itself), the other is the non-geographic space (the abstract information portrayed on a map) (Fuchs and Schuman, 2004). In conflict maps, these two components are interdependent and shape each other. Conflict-related events are embedded within a geography, which determine how they come into being and unfold. At the same time, conflict events can change local, regional and national geographies and power relationships (Rech et al.2015).

- *Static and dynamic components:* A map can display two sets of information: static information that does not substantially change over the time (e.g. the location of a capital and main cities in a country) and dynamic information that are influenced by new events and developments (e.g. power hierarchies within a region). Eventually, a map is a story-telling tool and data shown largely depend upon the narratives that lie behind the construction of the map. For example, if the analysis indicates that a conflict is driven by a competition over natural resources, it becomes salient to present the distribution of these resources across the country. In turn, the map furnishes a further support to the argument that the theorised correlation does exist.

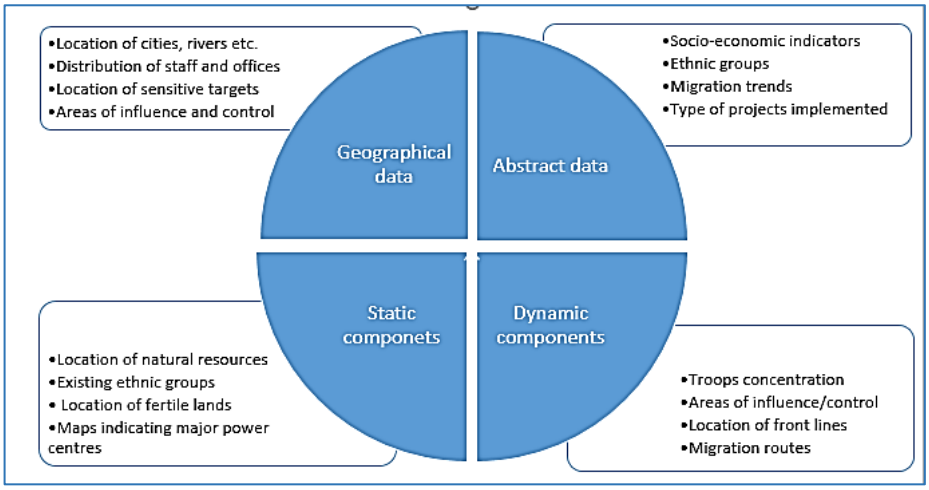

Figure 4: Components of a conflict map

1.2. Features of crisis and conflict mapping platforms

We describe below some common features offered by crisis and conflict mapping tools and platforms. These functions allow users to access more or less easily to a wide plethora of information and extract from this the awareness of the dynamics determining the onset and unfolding of crises worldwide.

OPEN ACCESS FORMAT: many crisis and conflict mapping tools are available in open access format, namely that their content is publicly accessible and no authentication or fee is required. This is true for tools such as Humanitarian Open Street Map, ACLED and LiveuaMap.

DYNAMIC INTERFACE: in most of the cases, mapping platforms display a dynamic web interface, which enable the user to move around the map and make interactive actions to change the information visualised. In other cases, as it is for the location maps available on Reliefweb, the web interface offers only a catalogue of static maps and the possibility of interaction is limited.

VISUALISION OF SPATIO-TEMPORAL DATA: it is obvious to say that the main dimension considered by all the mapping platforms is spatial. In other words, maps display data by their specific geographical coordinates (latitude and longitude). Some platforms with a dynamic interface offer also a time-dependent display, allowing to navigate through data by their temporal coordinates (e.g. when an event occurred). This

feature is offered by platforms such as ConflictView, LiveuaMap and ACLED. This further dimension makes more evident the evolution of a situation over the time.

AVAILABILITY OF A LEGEND: Almost all the mapping platforms supply a legend with the symbols used to depict the information on the map. This feature makes the maps easily readable.

MULTIPLE UNITS OF OBSERVATIONS: The unit of observations may differ between tools. For instance, ACLED offers events-based maps meaning that they mainly focus on the location of violent events. WarViews mainly depicts the location of actors, resources and conflict events. Other mapping platforms, like Humanitarian HOT maps and Reliefweb maps, do not have a specific focus and display various information layers, comprising the location of administrative (e.g. cities) and geographical features.

EXPORTABILITY OF THE DATA: Some tools allow exporting the dataset on which the information displayed on a map is based. This feature permits the user to manipulate the data and extract new information. ACLED and Humanitarian OpenStreetMap are examples of mapping platforms that offer this feature.

VISUALISATION OF THE INFORMATION SOURCES: In few cases, the list of information sources is made available. For example, LiveUAMaps and Ushaidi display the news feed, from which the information on the map is retrieved.

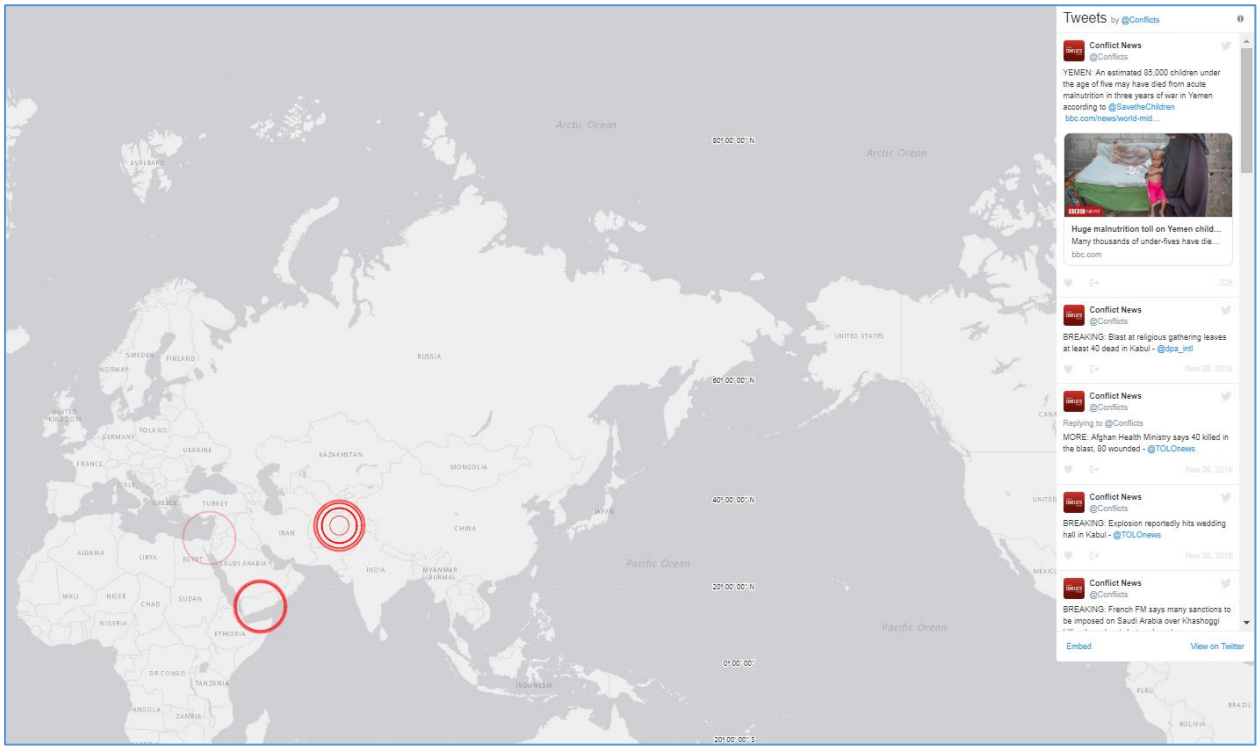

Figure 5: Science4peace web interface. On the right, the interface displays the list of recent tweets on Conflicts and the same events are geo-located on the map interface.

EASILY EDITABLE: In some cases, mapping platforms allow users to edit directly the map by adding new information. For instance, Humanitarian OpenStreetMap and its humanitarian branch HOT is a publicly editable map tool. The platforms with this feature usually allow viewing also the history of the edits made to a map.

DATA ANALYTICS: In most of the cases, mapping platforms and tools accompany maps with charts, graphs and diagrams or permit the user to construct them from the dataset. In this way, it is possible to visualise trends and patterns in the phenomenon analysed.

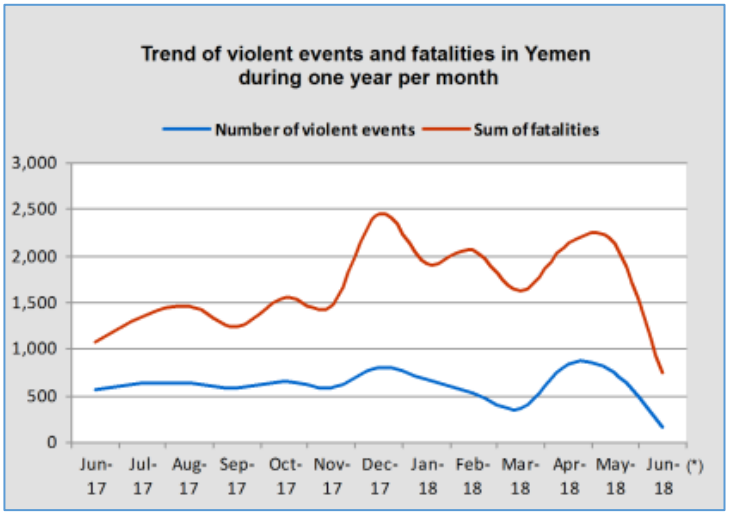

Figure 6: Trends in violent events and fatalities in Yemen from June 2017 until June 2018.

SELECTIVE VISUALISATION OF DATA: In most of the cases, mapping platforms allow the user to choose what type of data to visualise by using filters. This function permits to disaggregate data by free text, region or geographical extent for example

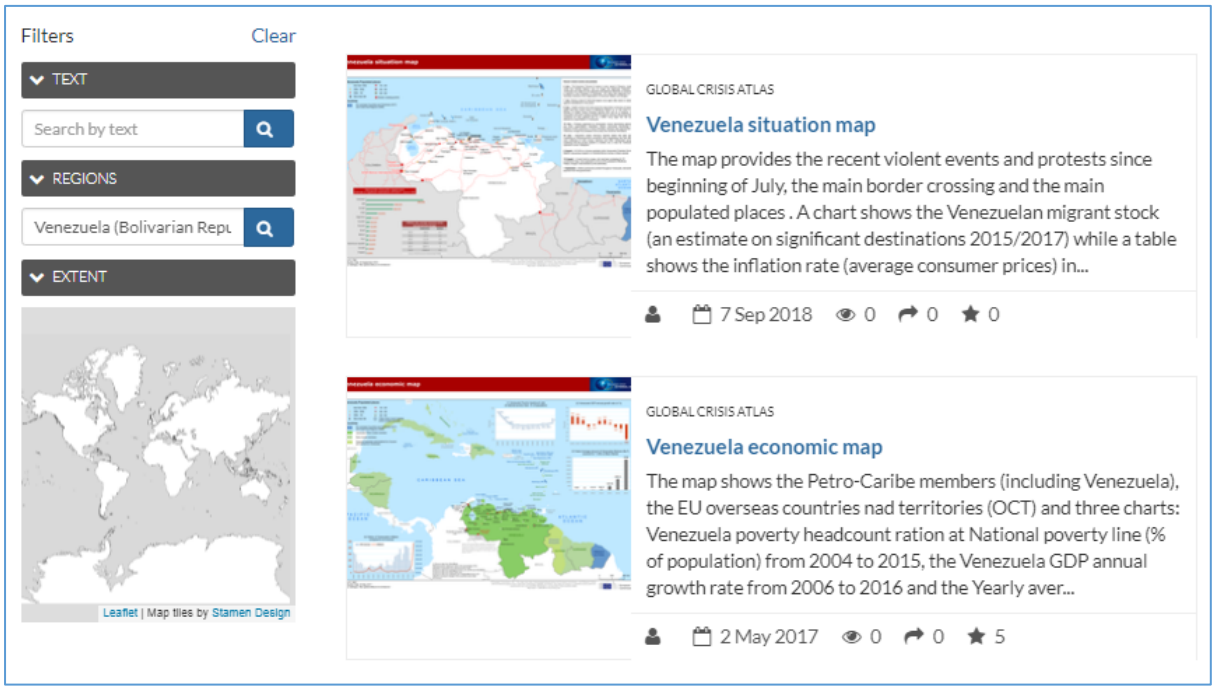

Figure 7: Visualisation of data by filters, Science4peace website

GEOGRAPHICAL BRUSHING: Many mapping tools with a dynamic and interactive interface allow the user to explore the map by zooming in (or zooming out) certain locations. This feature permits to focus only on the location of interest. Humanitarian Open Street Map, ACLED and ViewConflict offer this feature.

1.3. Presenting Global Crisis Atlas

In the next chapter, we will present Global Crisis Atlas (GCA), a repository of digital maps used to monitor strategic geographical areas or issues of interest (e.g., migration flows). As we shall explain, GCA is a situational awareness tool that provides support to the work of the EU External Action Service (EEAS) and the service for Foreign Policy Instrument (FPI) of the European Commission. The information conveyed through the maps contributes to the monitoring and analysis of crises that might have a direct or indirect impact on the European social, economic and political system.

2. The Global Crisis Atlas Project

Conflict prevention and peace-building is a recognised priority of the European Union. This includes the adoption of a comprehensive approach to tackling external conflicts and crises. In 2014, the EU launched the **Instrument for Stability and Peace (IcSP),** taking over from the Instrument of Stability, with the stated scope of providing short-term assistance to unfolding crises and long-term planning to address transnational and emerging threats. The IcP promotes and funds activities linked to crisis response and preparedness as well as to conflict prevention.

The Joint Research Centre of the European Commission (EC) is the scientific and research support service of the European Commission. As such, it provides methods, technologies and tools to improve the operational and policymaking activities of the EC. Created by the JRC, the Global Crisis Atlas (GCA) is financed by the IcSP framework and aims to build situational awareness during crises and conflicts through the provision of a combination of geographical and non-geographical information. As previously explained, conflict and crisis prevention and management activities, rely extensively on enhanced situational awareness for decisions that maximise positive impacts and reduce potential harm. In this view, GCA has as ultimate objective to support the work of the European External Action Service (EEAS) and of the Service for Foreign Policy Instrument (FPI) by ***providing the context to understand, monitor, anticipate, prevent and respond to current or potential risks associated with the emergence of crises.***

Accessible by the means of a web interface, GCA offers a **catalogue of digital maps** revolving around crisis preparedness, response and coordination. The term "crisis" is intended here as a critical event precipitated by either a competition among two or more parties (conflict) or by natural hazards (e.g. earthquakes, climate change, and drought) (Bugajski, 2011) or by socio-economic and political instability. The maps portray an overview of the situation in countries of interest and of unfolding crises, bolstering timely information exchange and real-time common situational awareness during major emergencies or crises.

The role of GCA is threefold:

- **Knowledge repository**: maps created by the GCA analysts are stored within the GCA portal, thus supplying an historical knowledge base of crises relevant to the EU policy and an analytical instrument to understand key issues and trends.

- **Crisis mapping**: the GCA analysts may engage in the mapping of specific conflicts and crises depending on ad-hoc requests submitted by EEAS and FPI. Maps may display a wide array of data such as the location of critical infrastructures within a country or the areas where a violent conflict is occurring. Crisis and conflict maps are usually backed with background information to understand the geopolitical situation of the country.

- **Situation assessment and monitoring**: Along with ad-hoc products, the GCA analysts works also on weekly monitoring products, documenting the developments of crises of specific interest for the EEAS. These mapping products are sent to EEAS together with the weekly EU Situation Room headlines.

The Global Crisis Atlas is a powerful **analytical and monitoring tool**. It complements the information provided by the EEAS monitoring service by graphically showing the geographical determinants of critical events. GCA maps integrate also background information and graphs that facilitate the correct interpretation of the map and reveal situational trends and patterns.

GCA maps help to respond to critical questions such as:

- What is the situation on the ground?
- How are development and cooperation projects distributed across a region?
- Where are the country's access points and critical infrastructures?
- Where are terrorist groups/attacks concentrated?
- What is the geography of ethnic groups within a country and what are the emerging power hierarchies?
- Where potentially sensitive targets (EU Embassies, EU delegation, Government buildings, etc.) are located?
- How to access the main airport, roads etc.?

Responding to these questions is vital to take decisions that lead to positive outcomes. The advantages of using this tool for EU policymakers are evident in terms of:

- Having in-house service and experts for the analysis of primary and secondary sources
- Making conflict and crisis- related data easily accessible and interpretable with the support of graphs and tables
- Visualising the spatial determinants of crises and conflicts, thus making evident where and how to allocate resources in order to maximise the impact of the intervention.
- Making sense of data, information and knowledge to underpin evidence-based policy making

Box 3: Why the Global Crisis Atlas?

Given the sensitivity of the information contained on some of the maps, the access to the portal is protected through appropriate authentication process and different access privileges.

Main beneficiaries of the GCA services are the EEAS and its intelligence centre INTCEN (EU Intelligence and Situation Centre) and the Foreign Policy Instrument (FPI). However, maps can be requested also by other affiliated institutions for specific purposes. As a rule, any request of access to the maps is notified to the FPI and processed by the JRC analysts. As of September 2018, GCA has 150 users. Figure 8 maps out the users of the GCA service.

The delivering of the maps occurs on a regular basis (e.g. weekly or biweekly) as result of a previous agreement on the monitoring of certain countries or crises of interest as well on an ad-hoc basis, namely as a result of a specific request by EEAS.

Maps are populated with data derived from **remote sensing intelligence** and **open sources analysis**. In the next section, we shall explain the procedure for data collection, validation and dissemination.

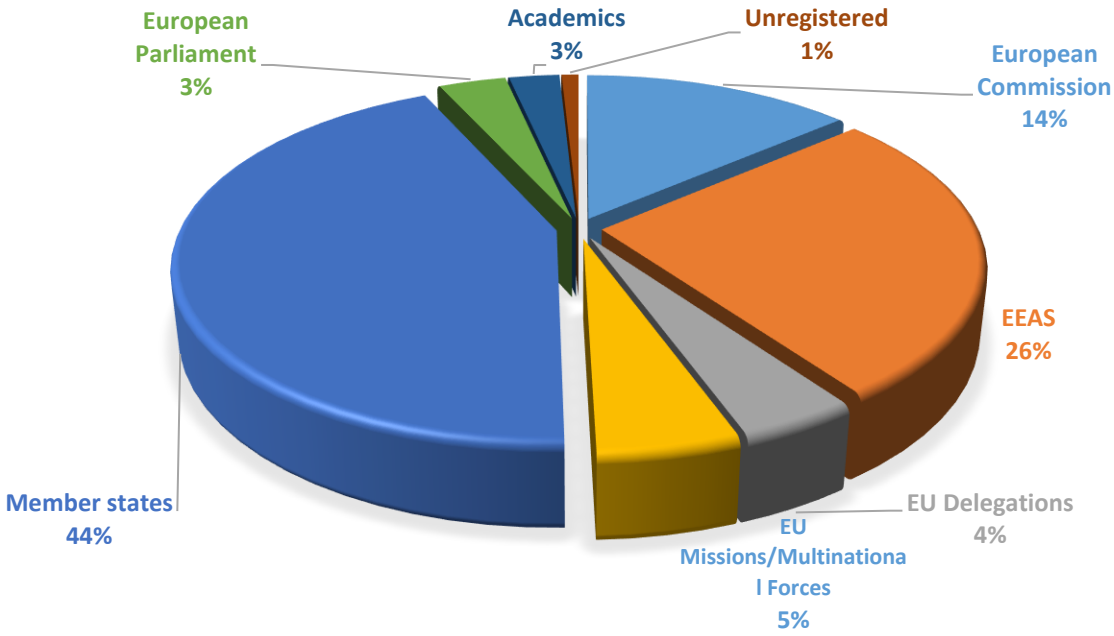

Figure 8: Users of the Global Crisis Atlas portal (as at September 2018)

2.1. GCA maps as a finished intelligence product

GCA maps are to be considered a "*finished intelligence product*", namely a product that "*has completed the rigorous, all-source correlation, integration, evaluation and assessment that enables it to be disseminated*" (Hedley 2009, p. 213). Data acquisition and reporting follows the steps of the intelligence cycle (Figure 9). This procedure guarantees the reliability of data sources and the validity of data processing.

Below we describe the steps of the intelligence gathering and how each step is fulfilled by the GCA analysts to produce the final output.

Direction: Every intelligence product starts off by a request of a decision maker who sets a list of intelligence requirements. In the case of Global Crisis Atlas, the intelligence requirements (i.e. which information is needed and in which format) are established by the European External Action Service, which also represents the final user of the product.

Collection: JRC analysts combine geospatial intelligence (GEOINT) and open source intelligence (OSINT) to collect data that set the foundations for the final maps. Geospatial intelligence refers to the "*exploitation and analysis of imagery and geospatial information to describe, assess, and visually depict physical features and geographically referenced activities on the earth*" (US National Geospatial Agency, 2018). Open source intelligence harnesses information supplied by publicly available sources (e.g. the Internet, traditional media outlets, conference proceedings and think thank studies) to derive insights. JRC analysts engage in the regular monitoring of official secondary data sources and extract information that is then reported within ad-hoc templates. Data are retrieved from a vast array of sources and triangulated with geospatial observations. They are stored in geospatial databases, making it easier to reuse them to create other products. Table 1 details some data sources monitored by the GCA analysts to retrieve the "intelligence" needed to compile the maps.

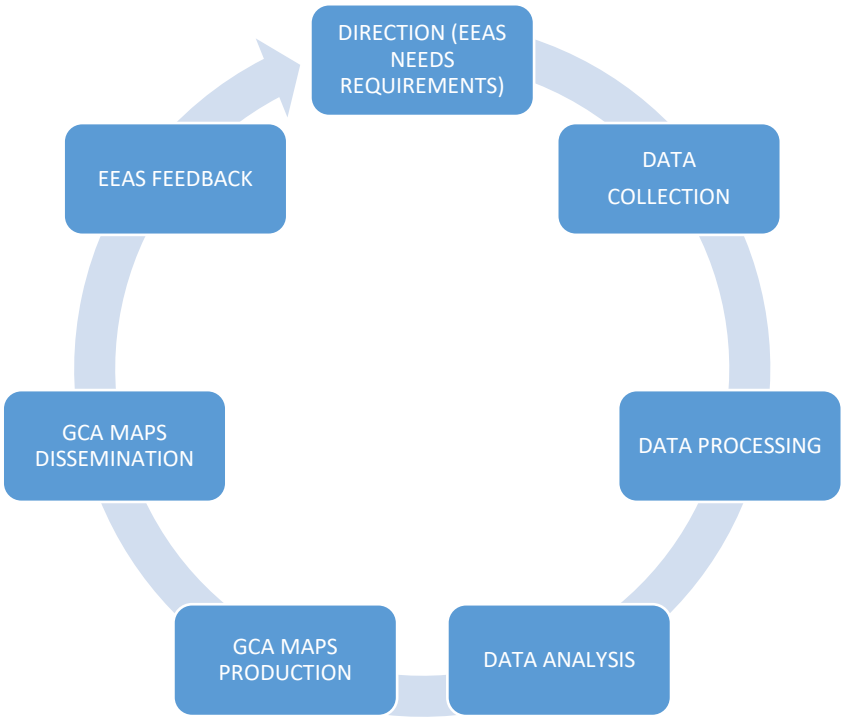

Figure 9: The Intelligence Cycle. From intelligence request to the GCA intelligence output

Geo-Spatial and non-geospatial processing: Once collected, data are processed in order to give them a spatial dimension necessary to produce the layers to be plot in the map layout. This might include, for example, convert the ACLED database on armed conflict events into a pivot table where the events are aggregated by populated places with a geographic coordinate and a list of non-spatial attributes related to the description of the events. Other common geo-spatial processing concerns the digitalization of information from scanned maps or maps in electronic format previously co-registered to the Coordinate System of reference. In addition to this, other non-geospatial data processing can be performed such as evaluating the relevance of the information, weighting the reliability of the sources in case of discrepant information and ensuring data validation through triangulation. This step permits the transformation of raw data into usable information.

Analysis: The next step (*analysis)* involves the process of connecting the various pieces of information and situating them within a context that enrich their meaning and value. In the GCA maps, geographical attributes are combined with other type of contextual data, which are usually presented in the form of diagrams, charts and tables. These graphs help to visualise the trends and patterns in the phenomena under analysis (i.e. a country's economic indicators during the past five years).

Production: The production of GCA maps occurs by the means of ArcGIS software. The next section of this chapter describes in detail the procedure followed for the production of GCA maps.

Dissemination*:* Finished GCA maps are sent via email to EEAS. In the case of the weekly monitoring products, maps complement the weekly EU situation room headlines by adding a geographical reference of the critical events which occurred during the week in the monitored area/country. The External Action Service may disseminate the maps to an internal distribution list, consisting of member states, EU DGs and other affiliated organisations whose work may benefit from the use of the product (see Fig 2.1.). The GCA maps are also stored into the portal, whose access is restricted only to authorised people.

Feedback*:* EEAS receive the map and provide feedback in case any additional inputs is required in order to meet the intelligence requirement. The improvement of the maps' contents and quality require a constant collaboration between the JRC analysts and the end user and the review of relevant emerging issues.

Name	Examples	Description
Institutional websites	IOM, UN Institutions, FAO, WORLDBANK DATA PORTAL, INTERNATIONAL MONETARY FUND, NATIONAL STATISTICS OFFICES	Official websites of international organisations represent the main source of information for GCA maps. They guarantee reliable and always updated information of the countries/events of interest. They also provide contextual information (e.g. GDP, water and land user) at country level.
Specialised news agencies and websites	EUROPE MEDIA MONITOR, NEWSNOW, SOUTHFRONT, LIVEUAMAP, REUTERS, ACF.	JRC analysts monitor constantly all the major news agencies publishing in various languages as well as news aggregator websites specialised on conflict and geopolitical analysis. In particular the Europe Media Monitor (EMM), developed by the JRC, analyses and aggregates both traditional and social media
Social Media	@SURIYAKMAPS, @MILADVISOR	Social media profiles of expert advisors and news agencies are monitored to collect the last updates about countries/events/actors of interest.
Technical report/specialised publications	INSTITUTE FOR THE STUDY OF WAR HTTP://ISWRESEARCH.BLOGSPOT.COM/ INTERNATIONAL CRISIS GROUP HTTPS://WWW.CRISISGROUP.ORG	Technical reports and publications from field experts and research groups provide an invaluable source of information to understand conflict dynamics.
Open sources databases	ACLED, ESRI	Open source databases offer a great deal of information about conflict and non-conflict trends.
Academic	ETH Zurich	Academic institutions publish papers with analysis of conflict dynamics and root causes regularly.

Table 1: Type of information sources monitored by the GCA analysts to populate the maps

2.2. Production and content of the maps

GCA maps are produced using **ArcGIS software.** ArcGIS is a mapping tool that allows for advanced location-based analysis and the visualisation and identification of spatial patterns. It performs a wide range of common GIS (Geographical Information Systems) tasks as well as specialized tasks like executing a geo-processing model or script. It allows switching layers on and off, querying features to access the rich attribute data that is behind the map and it supports scalable full-function editing. The user can print maps from the simplest to the most sophisticated cartographic product.

Each GCA map consists of a **set of layers**, displaying key elements for the understanding of the determinants of a crisis or conflict. The main dimension considered is ***spatial***, meaning that the information is injected into the map based on its geographical coordinates (e.g. deployment of forces within an area). Once the geographical distribution of the information is clear, the map can be enriched with additional non-geographic attributes presented in a graph or table format. The maps are static: they depict a crisis or conflict setting at a certain time. However, for the specific case of the weekly monitoring products, a temporal analysis on the evolution of the situation can be performed by comparing the maps produced in the previous weeks or months. Moreover, any changes in the layers (i.e. armed group's controlled area) is tracked into a database in order to make readily evident any increase or decrease (calculated in km or hectares) of the monitored/affected area.

A coordination meeting is planned in Central Asia for April 2018. We expect the major government representatives of the countries in the region to attend this meeting. Thus, we require support from the Global Crisis Atlas team for the collection of strategic insights into the region of interest. The request includes two maps, containing the following layers:

MAP 1 – For five countries in the region, we require: a) main populated places; b) the sources / management and use of water; c) the dams and the canals (existing and in construction); d) the upstream countries. Also we need 2 (two) charts showing each country's dependence on internal/external sources of water and use of water in % (human consumption, agriculture, industry)

MAP 2 – This should show the population density for the five countries plus a series of charts: total population; GDP per capita; % of remittances /GNI; % oil /gas in the GDP and % agriculture /GDP.

The maps should include 7 layers and 7 charts in total.

Box 4: Example of request

The **unit of observation and the content** of the maps vary considerably, depending on the intelligence requirements. The production of the maps requires a multidimensional, multi-level approach because of the complexity of the intelligence requirements set out by the end user. Box 4 describes an example of intelligence requirement which GCA analysts may be requested to fulfill. As a matter of fact, every map includes basic information about the country/city/region under examination such as its regional and international boundaries, main cities, road networks and geography features (rivers, lakes, mountains etc.). This information can be topped up with additional strategic elements like distribution of ethnic groups, natural resources, disputed areas, military facility deployment, location of embassies/EU delegation at city level, location of violent events, airstrikes, refugee camps, deployment of armed forces and their area of influence /control. The choice of which information to display is also dependent upon the identification of underlying conflict and crisis drivers.

The **graphical representation** of data occurs by standardised symbols. GCA analysts have established and agreed with the end users a list of common symbols, sometimes also using those provided by ESRI as a benchmark.

2.2.1. Categories of the maps

The GCA maps are divided into categories, each of whom is then further divided in sub-categories. This facilitates navigation through the maps and access to the content of interest. Below we describe the categories and the information they contain.

BASELINE MAP: *Baseline maps refers to maps displaying basic geographical information such as the location of borders, cities and critical facilities (e.g. main roads, ports and airports) at country, city or regional level (e.g. Horn of Africa). The category includes also administrative maps showing the areas under different administrative control and border maps, representing the areas close to the borders between two countries. Furthermore, it includes maps displaying the countries belonging to regional cooperation organisations (e.g. NATO countries or ASEAN countries).* Annex 2 features an example of a baseline map.

Sub-categories*: country maps***,** *city maps***,** *border maps***,** *administrative maps***,** *regional cooperation maps.*

POLICY MAPS*: Policy maps display the location of projects, interventions and initiatives in critical areas of the world as well as the distribution of offices and staff of international organizations in these areas***.** Annex 2.3 presents an example of a policy map.

NATURAL HAZARDS: *Maps under this category mainly deal with damage assessment and display the extent of the damage occurred in the wake of natural hazards (e.g. typhoons or earthquakes). Either they present a general overview of the damage which occurred at national or city level or give detail on the losses in a specific sector/area (e.g. loss of agricultural activities, bridges affected by an earthquake).* Annex 2 portrays an example of natural hazards map.

Sub-categories: *Damage assessment (general), damage assessment (specific*).

CONFLICT MAPS: *Maps under this category portray the situation of international armed conflicts (opposing two or more States) and non-international armed conflicts (between governmental forces and non-governmental armed groups, or between such groups only). They usually consist of maps monitoring a specific conflict over the time (e.g. following the evolution of the conflict dynamics on a weekly basis) and therefore every map is accompanied with the date to which the map is referred. They can either present a general overview of the situation or give details about a specific area/sector (e.g. vital sites bombed).* Annex 2 shows an example of conflict map.

Sub-categories: *Conflict situational maps (e.g. weekly updates), post-conflict damage assessment, conflict maps (specific).*

SECURITY THREATHS MAPS: *These maps display security threats, namely situations that might trigger a conflict or crisis. They can display, for example, the distribution of terrorist groups and attacks within a geographical area or the location of natural resources and potential sensitive targets (e.g. nuclear facilities). They usually deal with changes in the geopolitical power relationships and areas of control*. Annex 2 displays an example of security threats map.

Sub-categories: *Violent events***,** *non-state armed group activities/presence***,** *sensitive targets***,** *geopolitical changes.*

THEMATIC MAPS: *This category contains maps related to themes and issues of emerging interest or that might potentially trigger the outbreak of a crisis or conflict. For example, it might include information about socio-economic indicators of a country, distribution of ethnic and religious groups and of natural and non-natural resources and assets (e.g. oil pipelines and energy resources).* Annex 2 displays an example of a thematic map.

Sub-categories: *Socioeconomic indicators, Ethnic and religious groups distribution, natural and non-natural resources and facilities.*

MIGRANTS AND REFUGEES: *This category includes maps specifically dealing with the location of migration routes and refugees camps and giving information about the migration flows.* Annex 2 offers an example of migrants and refugees map.

2.2.2 Evaluating GCA's features and functionalities.

The score ranges between low, medium, and high depending on the extent to which GCA meets the target criterion. In the last column to the right, we present briefly an explanation of the given score. The table permits to visualize the potential areas for improvement of the GCA service and lays the groundwork for future directions, although still appreciating the differences and peculiarities between the GCA product and other tools available online.

2.2.3. Improvements to GCA service delivery and data visualisation

In chapter 3, we will be describing some of the ongoing projects that are underway to improve the functionalities of the Global Crisis Atlas service. As we shall explain, we are working on multiple aspects at once. First, we have focused on integrating the Global Crisis Atlas with other related projects under the peace and stability portfolio in the JRC E.1 Disaster Risk Management Unit at JRC. In doing so, we have highlighted the synergies between those projects and how they can work together toward a better understanding of conflict issues. Secondly, we are working around the development of our own conflict news database, taking advantage of the *headlines newsletter* provided by EEAS three times a day. Data will be then employed to inform the production of the GCA maps. Finally, we aim to expand our data sources to enrich our maps with new analytical perspectives and/or data.

Criteria	Score	Description
OPEN ACCESS FORMAT	Low	Access to GCA maps is free of charge but restricted only to authorised users.
DYNAMIC INTERFACE	Low	Since GCA is a catalogue of static maps, it is not possible to move around the map or click on the map to change the information visualised.
VISUALISION OF SPATIO-TEMPORAL DATA	Medium	Since GCA maps are static, no temporal view is available. However, for weekly monitoring products, it is possible a comparison with maps produced in the past for the same location.
GEOGRAPHICAL BRUSHING	Low	Since GCA maps are static, it is not possible to move around the map or zoom in certain locations
SELECTIVE VISUALISATION OF DATA	High	GCA users can filter the maps by region or by category (see the categories described in section 2.2.1.)
DATA ANALYTICS	High	GCA maps are accompanied with graphs, diagrams and tables that expand the geographical information and help reveal trends.
EASILY EDITABLE	Low	GCA maps are only editable by the JRC analysts. No other user is allowed to add information to the maps.
VISUALISATION OF THE INFORMATION SOURCES	High	GCA maps provide the source of information and the date of the last update.
EXPORTABILITY OF THE DATA	Low	The GCA portal does not allow users to extract and export data from the maps.
MULTIPLE UNITS OF OBSERVATIONS	High	For the conflict monitoring products, the unit of observation may include the location of violent events, natural resources and key facilities (e.g. airports) at city, country or regional level.
AVAILABILITY OF A LEGEND	High	Each GCA map is provided with a legend showing the graphical elements used to depict information on the map

Table 2: Evaluation of GCA functionalities against common features of crisis and conflict mapping tools

3. Further developments

Whist GCA contains static maps; it is not to be considered as a static service or tool. JRC strives to improve evidence based insights and technical service delivery, to satisfy the increasingly complex requests of the policy maker. For this reason, increasing emphasis is placed on developing new functionalities or improving data visualisation. Below, we describe some of the undergoing projects aiming to improve Global Crisis Atlas service, which encompass the integration of GCA maps into a bigger interface (Science4Peace portal), the creation of a conflict news database and the expansion of the information source database.

3.1. The Science4Peace Portal

Science4Peace is a project supported by the European Commission and aims at providing a collaboration platform for policy actors on the Instrument contributing to Stability and Peace, the EU INTCEN and its Operational Hybrid Fusion cell. The project taps into the synergies between three knowledge domains (remote sensing, statistics and geospatial technology) to provide a comprehensive tool for conflict risk prevention and early warning, situation awareness and monitoring as well as post-conflict recovery. By the combination of knowledge and tools across the entire conflict management cycle from prevention to recovery, it aims to offer a new perspective to analyse and effectively address conflict risks.

Figure 10: The homepage of the Science4Peace Portal

The project includes the delivery of a collaborative web platform (see figure 10), which seeks to bring together three different working streams: 1) risk indexes and statistical analysis for conflict prediction and prevention (represented by the Global Conflict Risk Index – GCRI), 2) geospatial analysis for early warning and situational awareness (Global Crisis Atlas) and; 3) post-conflict urban functionality analysis (Urban-S).The portal sheds light on the links between these projects, making evident the multidisciplinary and multimodal nature of conflict risk prevention and situational awareness. As such the Global Crisis Atlas data and services will migrate into the Science4Peace portal once it is fully implemented. GCA maps will appear as a distinct but also as an integrated part of the Science4Peace web interface. This will bring along some changes in the data visualisation.

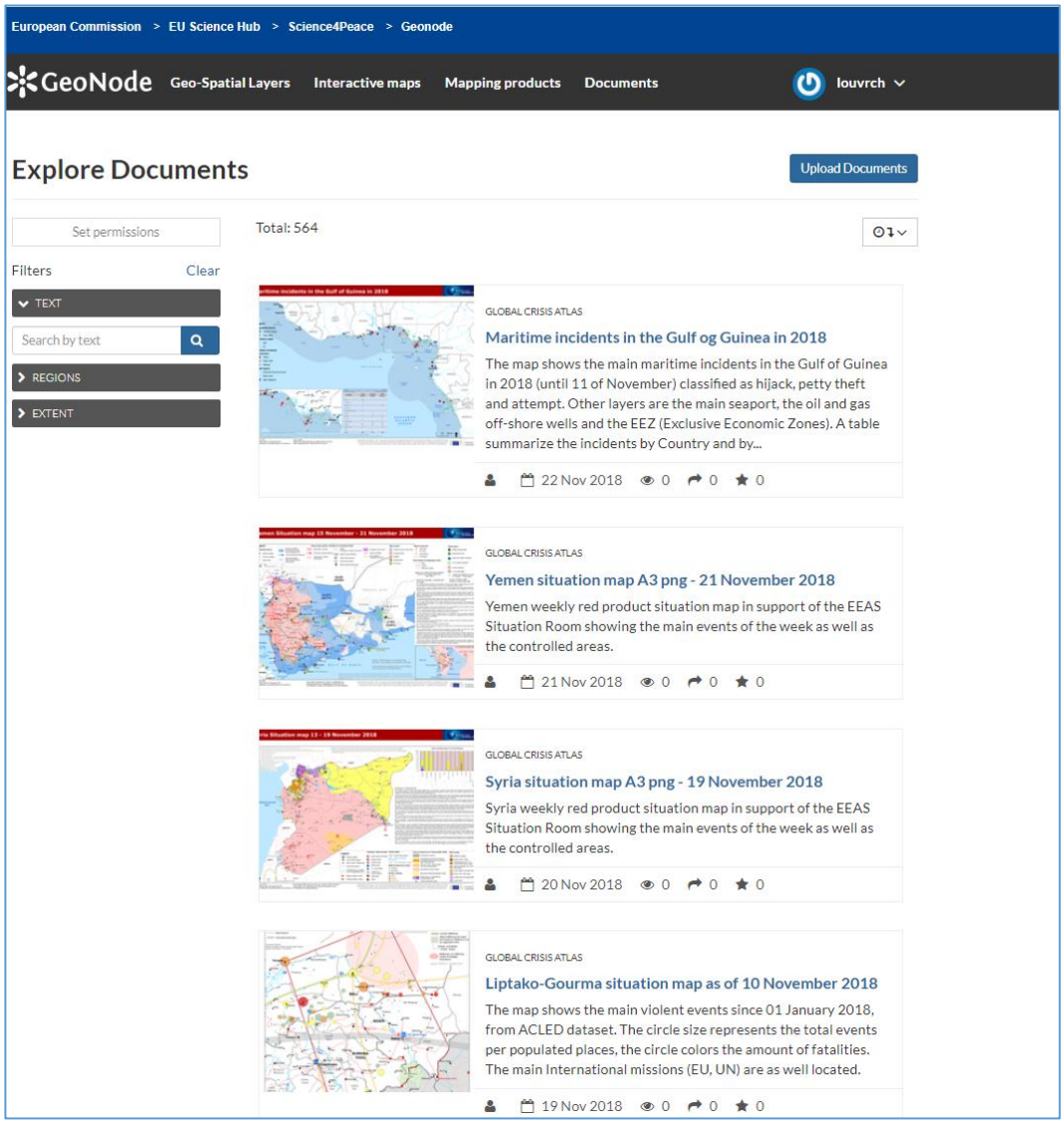

Figure 11: The section of GCA within the Science4Peace portal

3.2. GCA conflict news database

During the course of 2018, JRC has compiled a database of conflict news based on the Daily Headlines Newsletter sent out by the analysts of the External Action Service three times a day in an email format and reporting the news appeared on the major international media outlets on a topic or country/region of interest. As an example, the Syria monitoring newsletter includes sections on the military situation, diplomatic issues/international reactions and humanitarian/social issues.

The objective of the Conflict News Database is to archive the news included in the Daily Headlines newsletter in order to retrieve and analyze data and information through filters and queries, while having a spatio-temporal characterization of the monitored events. Data archiving serves two objectives: i) a source of verified information from which to draw data for the interactive GCA maps to be displayed on the Science4Peace portal; ii) understand better the topical issues and geographical areas that are of interest

for EU policy. In such way, policymakers are assisted in getting timely, geographically relevant information that can be incorporated directly in their decisional workflow.

To serve these objectives, we created a database, including conflict-related and non-conflict related news.

For the part of conflict-related news, we had to define inclusion and exclusion criteria. For instance, all news that referred to planned and future events were excluded from this section of the database. The same held true for general, vague and unofficial statements and speculations. Our conflict-related dataset factors in only the news that relate specifically to violent events (e.g. fights, riots etc.) or political developments that can lead to the outbreak of a conflict. In consideration that conflict events are highly time-sensitive, we deemed critical to highlight also temporal dependencies of one event over the other. The remainder news that were excluded from the conflict-related dataset, were then added into a different dataset labeled as "non-conflict related news". Currently, the injection of the news into the general database is done manually. However, GCA analysts are considering the option to automate this process by the use of artificial intelligence for data mining and categorization. More information on this is provided in Chapter 4.

Below we illustrate the main fields of the conflict-related news dataset.

Fields name and description

Event ID	A code made up of a sub-regional identifier (regional acronym), a date identifier (month-year) and an individual numeric identifier. A "start date" needs to be identified in order to begin coding the events.
Release date	Date (in dd/mm/yyyy format) in which the news of the event was released via EEAS Newsletter.
Event Date	Date (in dd/mm/yyyy format) in which the event took place, to be identified with the precise date of the unfolding of events.
Region (continent)	Regional and sub-regional country division according to the UN Geo-scheme for regional classification (see below).
Country	The country in which the event took place.
Admin1	The largest sub-national administrative region in which the event took place.
Admin2	The second largest sub-national administrative region in which the event took place.
Admin3	The third largest sub-national administrative region in which the event took place.
Location	The location in which the event took place.
Latitude	The latitude of the location.
Longitude	The longitude of the location.
Spatial influence	Sphere of territorial influence and interference (e.g. cross-border activities).

Temporal influence	One-day or prolonged event/expectation of continuance/prediction pattern.
Event type	The type of event (see below).
Actor 1 type	The actor type (see below).
Actor 1	The named actor or actors involved in the event (see below).
Actor 2 type	The actor type (see below).
Actor 2	The named actor or actors involved in the event (see below).
Summary	The description of the event presented in the EEAS Newsletter, keeping the language of release (English and French).
Information Source	The information source reporting the event.
Link	The URL of the information source reporting the event.
Fatalities	The reported deaths occurred during the unfolding of the event.
Keywords	Topics and details, in the hashtag format, which cannot be included in the main fields.

Event types

- **Armed conflict involving states and armed groups (state-based violence):** a conflict involving two or more governments (inter-state conflict), a conflict between a government and a non-governmental party with no interference from other countries or with foreign involvement (intra-state conflict) and a conflict between a state and a non-state group outside of its own territory (extra-systemic conflict).
- **Armed conflict between non-state actors (non-state violence)**
- **Violence against civilians (one-sided violence):** violence carried out either by a state actor or by an organized group against civilians.
- **Riots/ Protests**: if protestors are heavily injured in the course of a demonstration, the event is no longer marked as "Protest", rather as "Violence against civilians".
- **Human rights violations:** including forced population displacement, dispossession and deportations.
- **Political developments/ Relevant developments:** non-violent activities which are to some degree related to conflict situations, such as statements, announcements, agreements, meetings, policies, strikes, arrests, security measures and other events of strategic significance.
- **Other**

The classification of armed conflicts and events has been adopted partly from the Uppsala Conflict Data Program (UCDP) and from Armed Conflict Location & Event Data Project ACLED.

Geo-localization of events

An event is geo-localized according to the location in which it takes place. In case geo-localization of the event proves difficult, especially considering "Political and relevant

developments", the location will be limited to the general geographic area ("Region") according to the broad topic and regional context it refers to. If the event cannot be specifically localized, but clearly relates to a national context, then its location is associated with the national capital of the state in question. Other relevant details regarding the nature of the event can be provided in "Keywords" with appropriate hashtags.

The UN Geoscheme for regional and sub-regional country division is adopted.

- Western Europe (weu)
- Southern Europe (seu)
- Northern Europe (neu)
- Eastern Europe (eeu)
- Latin America and the Caribbean (lac)
- Northern American (nam)
- Northern Africa (naf)
- Eastern Africa (eaf)
- Western Africa (waf)
- Central Africa (caf)
- Southern Africa (saf)
- Central Asia (cas)
- Eastern Asia (eas)
- South-Eastern Asia (seas)
- Southern Asia (sas)
- Western Asia (Middle East) (me)

Actor types ("Actor 1/2 type") and named actors ("Actor 1/2")

Two fields are dedicated to each of both actors: one related to the actor type and one to specify the named actor, for a total of four fields. If more than two actors participate in the event, they are listed and divided between the fields associated to Actor 1 and Actor 2, according to the function and role they played while taking part in the event. Especially in the case of violent confrontations, in fact, "Actor 1" is associated with the perpetrator, while "Actor 2" with the target. The opposite occurs when considering "Political and relevant developments" – especially in the case of official statements – where often times the nature of the non-violent events they describe translates in the absence of a second actor.

- **Government and state security forces**
- **International organizations:** EU, NATO, UN, etc. and related military forces and missions (where applicable).
- **Armed groups:** these include armed groups in general as well as armed political movements and terrorist organizations (rebel groups, militant groups, paramilitary forces, militias and unidentified armed groups). The decision to group these different actors under one broad category is due to the fact that there is no official and univocal classification for each armed group, and at times classifications vary upon political considerations, creating therefore inconsistency throughout the database. The names of the groups, where possible, are to be kept in their national language rather than translated. Additionally, if a group is active in more than a country with a different organization, the name of the country should be included in brackets in the field of the named actor that is "Actor 1" and "Actor 2" [e.g. Isis (Libya).
- **Rioters/ Protesters**: nationality, membership organization or association, specifics of protesters in brackets
- **Civilians** (including representatives of political parties and social movements): the nationality of civilians is included in brackets in the field of the actor type [e.g. Civilians (Iraq)]. The field of the named actor, in this case, is to be filled in

case the civilian population in question is part of a minority, ethnic group or part of a social/political movement [e.g. Civilians (Myanmar); Hindus].

- **Other**

3.3. Expansion of the information source database

As previously explained and illustrated in table 2, GCA maps draw information from wide-ranging type of sources. However, as we come across new datasets or tools relevant to our work, those are added to a shared Excel sheet. The internal database so created divides new sources by their main topic of reference. For example, free online tool like the Aquasat, FAO's Global Water Information System, provides figures and spatial data about water resources and use at country level. This information becomes of critical importance if we are to design, for instance, a map highlighting areas where water resources are scarce; a condition that could possibly trigger the outbreak of a crisis. Annex 1 reports the information source database compiled by GCA analysts.

4. Future directions: toward an innovative approach to tackling conflicts

4.1. Where are we heading to?

The Joint Research Centre supports policy makers by providing evidence-based knowledge to understand, predict and possibly prevent conflicts risks. Against this background, GCA maps add a further level of analysis (i.e. geospatial analysis) that enables policymakers to better address risk associated with conflicts and crises. To explore new areas of crisis and conflict risk prevention and management, allowing for different analytical perspectives, disciplines and methodologies, the emergence of an innovative approach to peace research is required.

Peace innovation is an emerging discipline of study (Miklian and Hoelscher, 2018) that not only leverages on new technologies for peace-building activities but also invites to think creatively on how to build a society that is more inclusive and geared toward conflict resolution through peaceful instruments.

This chapter is set to draw the roadmap toward a new vision of conflict risk management and prevention. This vision is embedded in and manifested through the Science4peace portal and project.

The backdrop of this vision consists of three main pillars:

- **Being integrated:** This vision brings together spatial data, statistical methods and composite models and integrates them to build a meaningful picture of the conflict risk dynamics. Data in multiple formats and referring to different timescales (e.g. past historical trends, present structural conditions, and future predictive models) feeds into this vision. Figure 12 below describes the different levels at which data, methodologies and analyses are integrated.

- **Being multidisciplinary:** This vision combines and integrates knowledge from different disciplines. This, while recognizing that conflict risk prevention and management requires a holistic approach that fits the complexity of the conflict dynamics and root causes.
- **Being inclusive:** This vision remains open to new developments, inputs and perspectives although preserving a fundamental set of values and principles at its core. Theoretical and empirical knowledge suggests that inclusive, cohesive and equitable growth is an essential element for peace-building (OECD, 2018). For this reason, the roadmap to our vision for conflict risk prevention cannot be anything but inclusive.

4.2. Why do we need this vision?

This vision recognizes the inherent complexity of tackling conflict risk dynamics and root causes. It acknowledges that intertwined events, actors and contextual elements feeds into the emergence, development and resolution of conflictive situations.

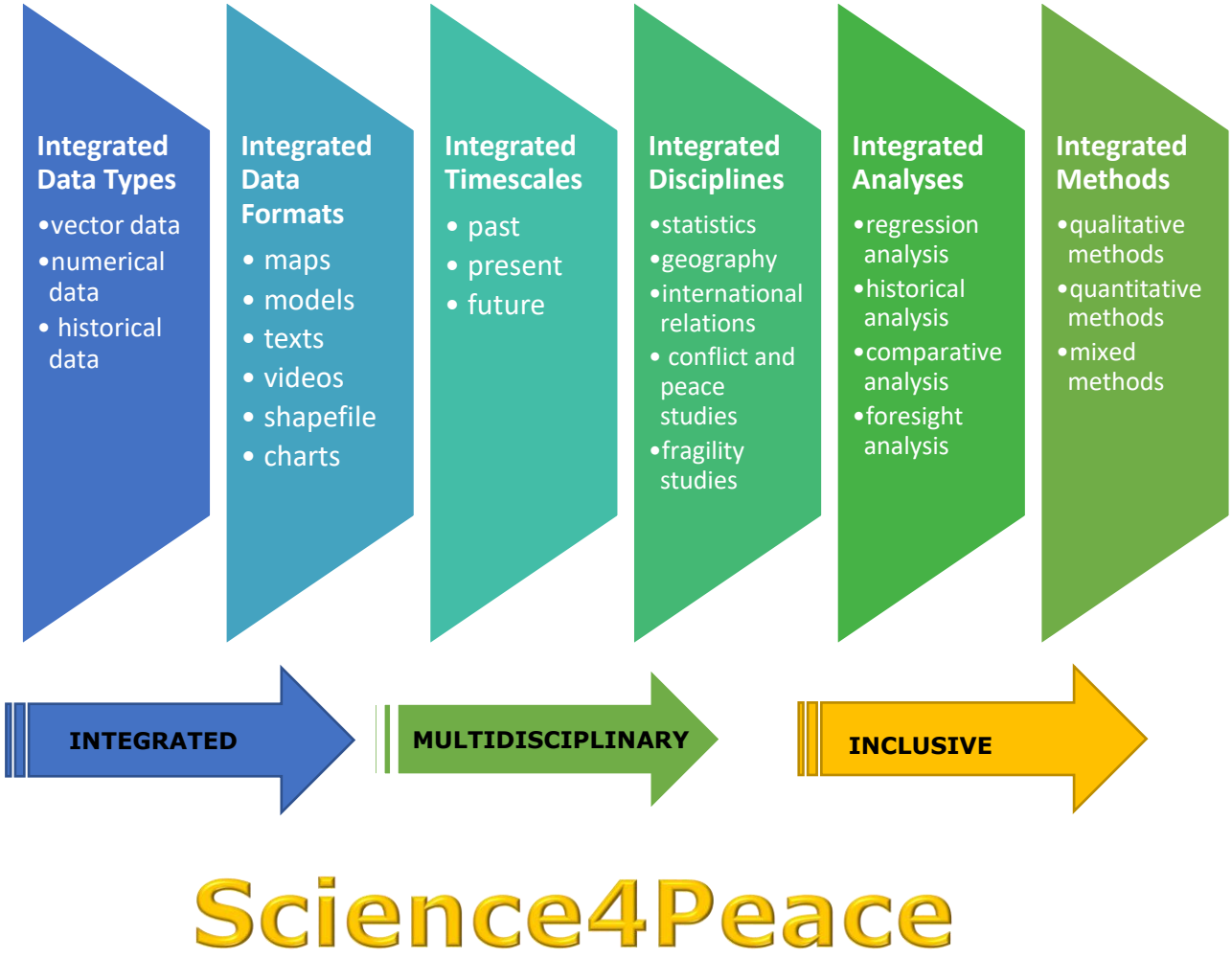

Figure 12: The vision embedded in and manifested through the Science4Peace project

Thus, this vision is needed in order to:

- **Analyse**. Conflict analysis is a powerful instrument for understanding and managing conflicts. It includes an in-depth exploration of conflict causes, of the position, interests and needs of intervening stakeholders. It sheds light on contextual elements and dynamics driving the conflict's evolution over the time. In view of such complex analysis, an integrated, multidisciplinary and inclusive approach is a requirement.

- **Predict** The Global Conflict Risk Index (GCRI) developed by JRC already embeds in -house conflict prediction capacities at country/year. However, in order to increase predictive performance, modeling tools need to integrate data, analyses and methodologies at various levels and geographical scales and as such, incorporate inputs from various knowledge domains or actors.

- **Support.** Analysis and prediction efforts all flow into the support to policymaking and peace-building activities. As an example, JRC is actively supporting the assessment of urban functionality in conflict-torn cities in Syria, alongside other humanitarian actors. This project contributes to positioning the EU as a global leader in post-conflict recovery frameworks and to fulfilling one of

the President Juncker priorities of the European Union, namely to support peaceful and inclusive societies in its role in the global context (EU as a global actor).

4.3. What do we need to implement this vision?

To implement the vision for a new crisis mapping service we need on one hand content management innovations to enable the cross-fertilization of data and information from different domains or geographical scales, as well as on the other hand, we need to change the sectorial way of handling data for risk prevention, as separate from those on crisis mapping or post-conflict assessment, hence from project-based knowledge production toward one that is more integrated, multidisciplinary and inclusive.

In the subsections below, we describe some of the technical improvements that the GCA analysts are working on to deliver the vision just described. We envisage that the implementation of each of these steps will bring us a bit closer to the final objective of adopting and incorporating a new approach toward the anticipation, comprehension and settling of global conflicts and crises.

4.3.1. GCA dynamic interface

An important improvement we aim to achieve is the development of an interactive and dynamic interface for GCA maps. The expansion of web technology over the past decade has opened up a number of opportunities to presenting data online. One of the most rapidly improving tools for interactive presentation is the map. Interactive maps on the Internet **display data more effectively than print maps because they embed the function to call the user to action**. Several methods can be implemented in order to visualise a crisis or conflict interactively. Some methods allow visualising a conflict by its temporal evolution with the ultimate objective to render evident the elements that drive the rise, evolution and resolution of conflicts and crises. Examples of dynamic interface features are the following:

- CONFLICT DYNAMIC:
  - Show the evolution of a conflict / crisis over time where the user can select one or more time periods and perform comparative analyses.
  - To assign spatial attributes to the news collected in the weekly situation maps in order to make them available as an additional source of information, and as a historical archive of the "story" of the conflict.

- INTERACTIVE MAP COMPOSER:
  - Customization of geospatial layers' visibility.
  - Customization of geospatial layers' symbolism.
  - Implementation of an editing tool.
  - Pop-up menus/windows of layers' attributes.

This feature is expected to be used for policy and planning cycles not only related to conflicts or crises, but also for recovery and reconstruction frameworks as well as to portray the location (regions, districts, and place) of EU investments.

- GIS-BASED FUNCTIONALITY:

- Implement functionalities for editing geospatial spatial relationships between the layers. For example, a tool that can measure distance between two points of interest could be helpful for rapid evacuation plans in case of crisis or emergency.

- MEDIA INTEGRATION:
  - Complement the content of a map with media information (video, pictures, and social media feeds) and/or with graphic elements as charts.

We aim to implement one or more of these features most likely in a combined fashion. These features will consent to realise a number of objective such as:

1. The comparison of temporal dynamics of crisis and conflicts, thus connecting different timescales as envisaged in our vision and visualising the effects of temporal dependencies.

2. The exploration of spatial dependencies and of the interaction between contexts, events and people. This allows seeing the conflict or crisis as resultant from the crossing effects of human actions and socioeconomic and geopolitical factors.

3. An interactive map allows to "play" with the dataset on which the map is based and perform diverse analyses, aggregating or disaggregating data at various levels and using simultaneously multiple methodologies of analysis.

4.3.2. GCA story maps as a learning tool for conflict risk prevention

Once that the GCA dynamic interface has been fully designed and implemented, we can explore new ways of interacting with maps, therefore the backend design must flexibly allow for additional functionalities to emerge. One of the possible applications of GCA maps is conflict risk prevention through peace education. Educating to peace means to raise awareness on conflicts risks and conflict drivers so that people can better understand the underlying motivations and learn lessons from the past.

There are many ways to tell a story. Maps are simple and engaging instruments to visualise places, locations, people and relationships and tell complex stories. These stories can serve different purposes such as to supply information, inspire change, engage the user in an initiative or project. Currently story maps make great use of technology advancements and integrate multi-source and multi-format contents such as written texts, videos and images. Story maps usually provide much additional functionality to explore and interact with the content on the map. Interactive story maps are a powerful learning tool. A map user is no longer only a recipient of the information but also an active map producer; s/he can actively decide which content to visualise and the modes and times of visualisation.

The European Commission has recently released a set of interactive maps to inform about the many initiatives related to cultural heritage in Europe. This online tool mixes up narrative texts, hyperlinks, geographical information, videos and info graphics to raise awareness on the importance of cultural heritage in the European context.

Box 5: Maps as a storytelling and learning tool.

Nowadays, thanks to the advancements in information and communication technologies, educational material is conveyed through a multimedia and multi-format fashion. For instance, the same information can be communicated in the form of a narrative text, an audio interview or a video presentation. Story maps collapse multiple information

sources and formats into one place and enable the user to explore a certain topic by considering also its geographical determinants. For this reason, a story map is a particularly suitable instrument to understand and study conflict risk. As previously discussed, the GCA is currently intended as an instrument for technical experts to understand critical (and potentially critical) situations by visualizing actors, events, relationships and assets on a map, in the outbreak or unfolding of a crisis or conflict. Naturally, map information may be sensitive and subject to access restrictions.

A GCA story map may not only allow for thinking differently at how conflict and crisis data can be harnessed and visualized, but would also enable combination of diverse expertise and knowledge spheres in a multidisciplinary way.

4.3.3. Automation of data injection into the Conflict news database

As explained in chapter 3, the news derived from the EEAS Headlines newsletter are selected and injected manually into our database by the GCA analysts. However new opportunities for using artificial intelligence for data and text mining have become available. As a result, we are considering automating the process of data extraction and selection from the Headline newsletter and data injection into GCA news database. This procedure will expedite the processing and digestion of a large volume of data, freeing up resources to develop new functionalities and making available to GCA analysts filtered data to prepare the GCA maps. The figure 15 below shows the process of automation of data injection.

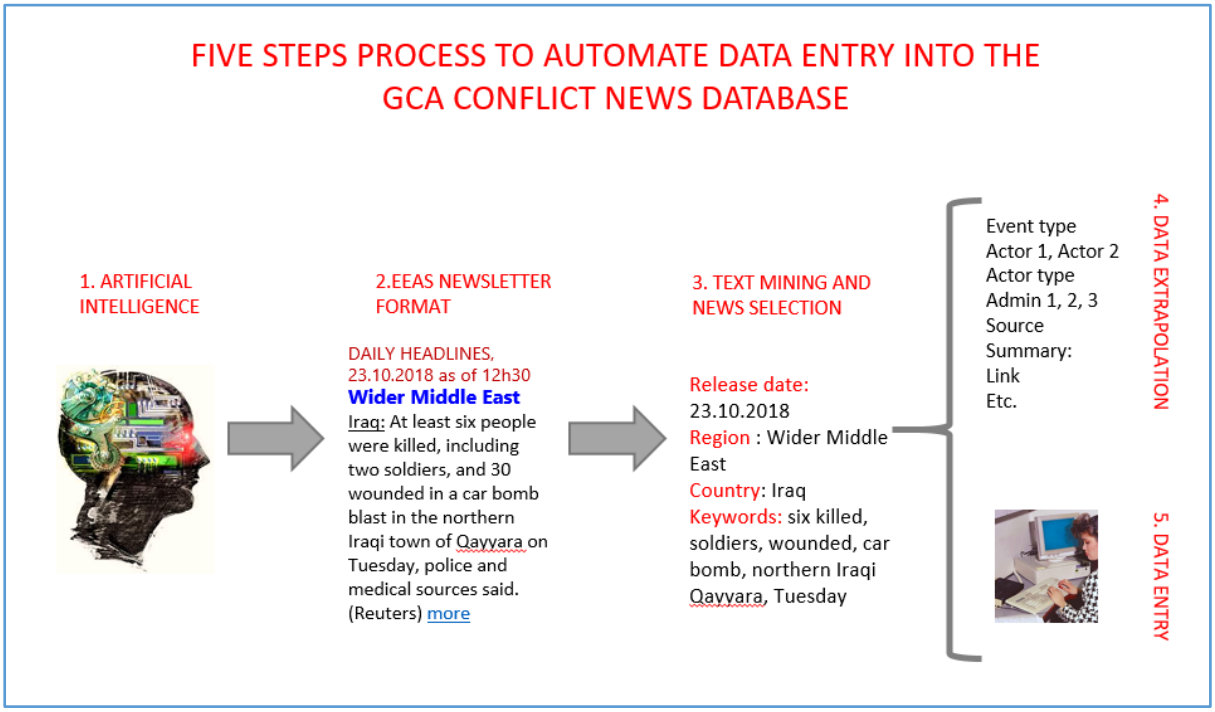

Figure 13: process steps of automation of data injection.

Another advantage of automation is that neural networks can learn to recognise the topics of interests as they are highlighted in the EEAS newsletter. Starting from this, they can be asked to expand the core information with additional data taken from a variety of sources. As a result, the information is augmented and reported back to EU policymakers who can use it to take critical decisions. In other terms, rather than waiting

for a specific intelligence request to be sent by EEAS or FPI in response to a critical or potentially critical situation, the GCA can provide tailored information proactively. The potential benefits of such service in terms of usability and richness of information are enormous.

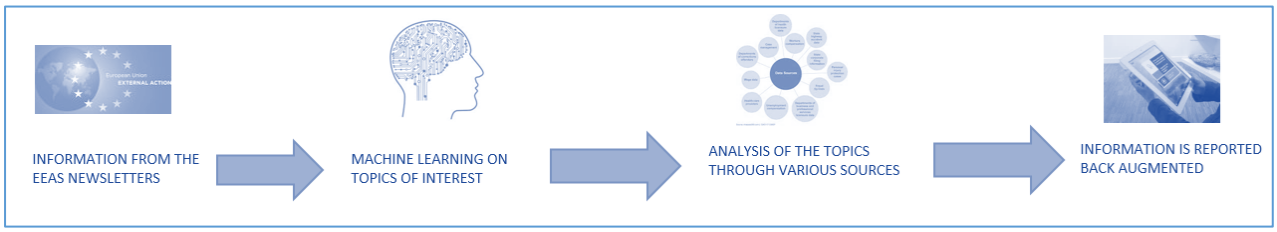

Figure 14: How machine learning can enhance information provided to our end user.

This is an example of good practice in the execution of the new crisis mapping paradigm: implementing data integration and multiple analyses proactively, to anticipate policy requests.

5. Conclusions and outlook

Our work is informed by the five values of the JRC strategy 2030: integrity, accountability, openness, inclusiveness and innovation. The vision described in chapter 4 and exemplified through the Science4Peace portal enacts these values:

1. It strives to deliver on our commitments toward FPI/EEAS and provides thoughtful strategic follow-up. The adoption of the mentioned vision, not only allow us to improve the crisis mapping service but also to support policymakers in the delivery of more impactful policies for Stability and Peace. (Accountability)

2. Our vision is based on principles of inclusiveness and integration. We value different approaches and perspectives to established knowledge and we use them to improve and innovate the conflict management cycle by integrated information management.

3. Innovation is the end goal of our vision. We commit to walk through unexplored itineraries and search for new means to pursue old and emerging goals.

In its current form, the Global Crisis Atlas provides a comprehensive picture of crises and conflicts affecting the EU system more or less directly. GCA maps are integrated with other information packages and employed by the External Action Service to design strategies, establish priorities and take decisions. Every map is purposefully designed to meet a specific intelligence request, wherein the geographical element is considered critical for the understanding of the situation and to foresee possible implications of critical events. Conflicts and crises have an inherent geographical nature because the connections and interactions between people, places and objects determine the dynamics of their onset and occurrence. Global Crisis Atlas taps into the advancements of Geographical Information System Mapping and the vast availability of open data online and combines these two sources into a meaningful way. As a result, geographical information are enriched and made more easily interpretable by adding non-geographical information from open sources.

The last two chapters of this report describe our efforts toward service improvement and innovation. Nowadays the rapid evolution and increasing complexity of crises and conflicts requires that technologies, methods and knowledge approaches adapt accordingly. The Science4Peace portal, for example, originates from the need to take advantage and combine our expertise in using composite statistical models and geospatial technologies for conflict risk prevention and management. This approach is well suited to the multidisciplinary and multi-faceted nature of conflict studies. On the same line, the development of an internal news database and the automation of the data processing has the objective to improve service delivery in terms of amount, type and level of interconnectedness of the data provided to our end users. This enhancement brings along benefits in the way in which crises and conflicts can be understood, anticipated and tackled by European policymakers. On a final note, we like to consider ourselves as partners in knowledge production, management and utilisation. This means that we are not only providers of knowledge on-demand but we work closely with policy makers to better understand the potential impacts of future trends on our society and in finding the most appropriate responses.

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List of abbreviation and definition

This section aims to clarify the meaning of key terms used throughout the report.

GCA: Global Crisis Atlas

JRC: Joint Research Centre

EEAS: European External Action Service

FPI: Service for Foreign Policy Instrument

Critical situation/event: it refers to a situation or event in which the combination of various elements brings to the loss of control over the factors influencing the situation. Critical situations or events are prodromal to the outbreak of a crisis.

Potentially critical situation: a situation encompassing several elements that, if combined in specific configurations, might lead to a critical situation/event.

Crisis: "*A disruption that physically affect a system as a whole and threatens its basic assumptions, its subjective sense of self, and its existential core*" (Pauchant and Mitroff, 1992, p. 15). In order to be defined as a "crisis", a situation needs to hold certain characteristics such as being fluid, instable, dynamic, and (usually) unexpected. A crisis can be precipitated by diverse events. In this report, we focus on crises induced by conflicts or natural hazards (e.g. earthquakes, drought, climate change etc.) (BUGAJSKI, 2011)

Conflict: the meaning of the term conflict varies widely depending on the context of reference. In this report, we refer only to armed conflicts, namely a dispute between two or more parties involving the use of armed force. There are two types of armed conflicts, as defined by ICRC (2008):

1. *International armed conflicts* exist whenever there is resort to armed force between two or more States.
2. *Non-international armed conflicts* are protracted armed confrontations occurring between governmental armed forces and the forces of one or more armed groups, or between such groups arising on the territory of a State [party to the Geneva Conventions]. The armed confrontation must reach a minimum level of intensity and the parties involved in the conflict must show a minimum of organisation.

Conflict Prevention: Measures to avert violent conflict and put in place the means to resolve future disputes non-violently. Strategies for prevention fall into two categories: operational prevention, which refers to measures applicable in the face of immediate crisis, and structural prevention, which consists of longer-term measures to ensure that crises do not arise in the first place or, if they do, that they do not recur (Reliefweb, 2008).

Conflict management: it denotes the employment of practices and techniques to handle a conflict in the effort to reduce its adverse impacts.

Conflict risk prevention: Analyses and measures carried out to better understand underlying risks associated with the outbreak of conflicts and crises and to address these risks.

Conflict risk management: Measure and techniques put in place to address and manage the risks associated with the emergence of conflicts and crises in order to minimise their adverse impact (i.e. prevent the outbreak of a crisis)

Geographic Information System (GIS) Mapping: "The use of a geographic information system, a computer-based tool, for risk or hazard mapping. GIS technology integrates database operations with the geographic analysis benefits offered by maps". (Reliefweb, 2008 p 25).

Hazard: A process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation. Hazards may be natural, anthropogenic or socio-natural in origin (UNISDR, 2017).

Prevention: Activities to provide outright avoidance of the adverse impacts of hazards and means to minimize related environmental, technological and biological disasters. (Reliefweb, 2008)

Geospatial intelligence (GEOINT): "*exploitation and analysis of imagery and geospatial information to describe, assess, and visually depict physical features and geographically referenced activities on the earth*" (US National Geospatial Agency, 2018).

Open source intelligence: exploitation of information supplied by publicly available sources (e.g. the Internet, traditional media outlets, conference proceedings and think thank studies) to derive insights into topics of interest.

Situational awareness: "*the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future"* (Endsley, 1995). In more operational terms, situational awareness allows one to understand the elements influencing a situation in the present ad in the future.

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ANNEXES

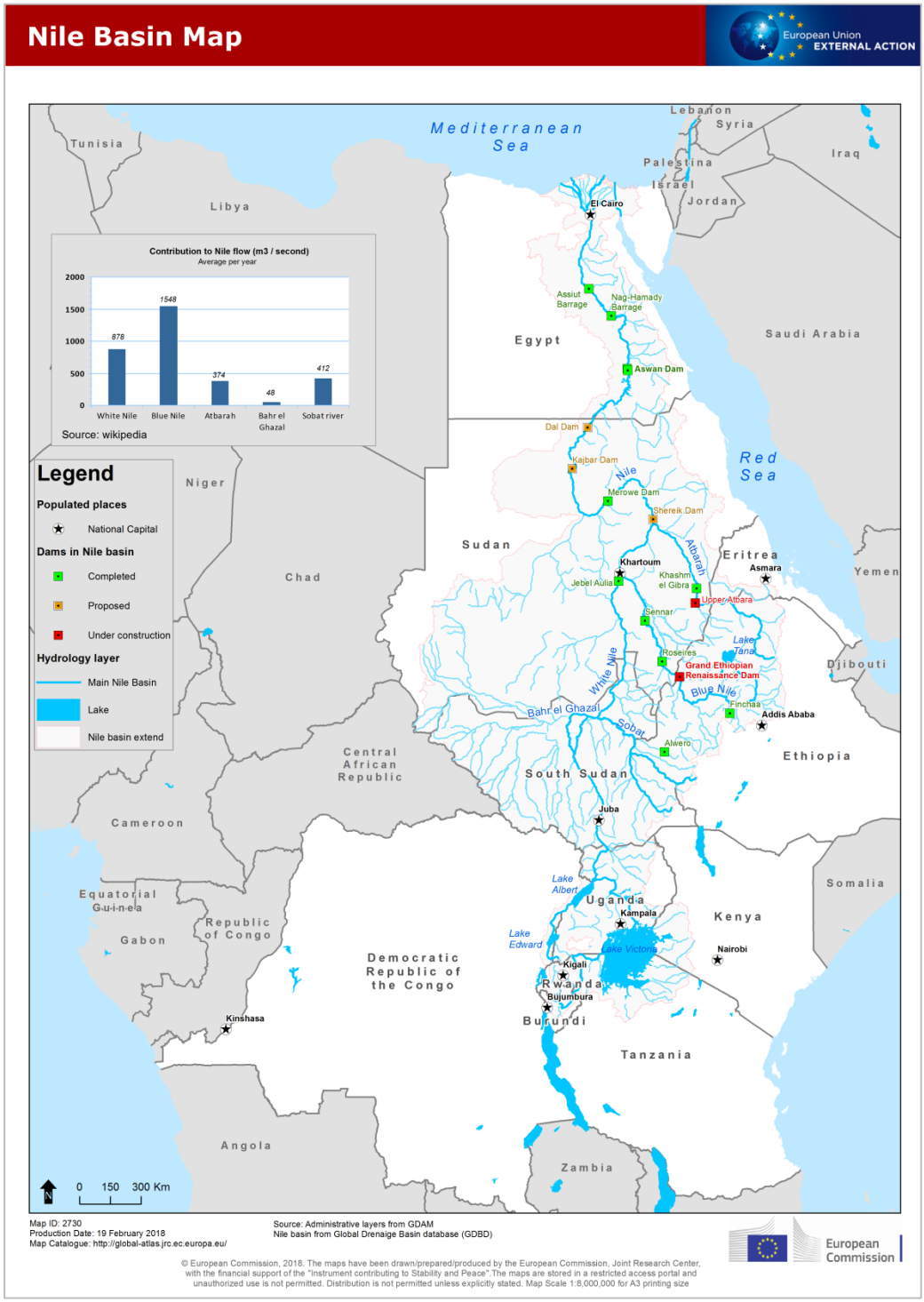
ANNEX 1. Not exhaustive list of information sources for GCA maps.

Name	Link	Purpose
CIA Maps	https://www.cia.gov/library/publications/resources/cia-maps-pul	Baseline maps
Nationsonline	https://www.nationsonline.org/oneworld/map/index.htm	Baseline maps
JRC Earth Observation Data	https://cidportal.jrc.ec.europa.eu/imagearchive/	Baseline maps
Ezilon Maps	https://www.ezilon.com/maps/	Baseline maps
Library of Congress	https://www.loc.gov/	Baseline maps
ACLED	https://www.acleddata.com/dashboard/	Conflict/general
Southfront	https://southfront.org/	Conflict/general
almasdarnews	https://mobile.almasdarnews.com/	Conflict/general
Antiwar.com	https://original.antiwar.com/	Conflict/general
CrisisGroup	https://www.crisisgroup.org/	Conflict/general
Grow (ETH)	https://growup.ethz.ch/pfe/Chad	Conflict/general
Geopoliticalfeatures	https://geopoliticalfutures.com/	Conflict/general
Critical Threats	https://www.criticalthreats.org/	Conflict/general
HumanRightsWatch	https://www.hrw.org/	Conflict/general
Institute for United Conflict Analysts	https://twitter.com/iucanalysts?lang=it	Conflict/general
IWN	https://twitter.com/A7_Mirza	Conflict/general
LiveUapMap	https://iraq.liveuamap.com/	Conflict/Iraq monitoring
Peto Lucem	https://twitter.com/PetoLucem?ref_src=twsrc%5Egoogle%7Ctwca	Conflict/Iraq monitoring
Southfront (Iraq)	https://southfront.org/category/all-articles/world/middle-east/ir	Conflict/Iraq monitoring
UnIraq	http://www.uniraq.org/index.php?lang=en	Conflict/Iraq monitoring
Musings on Iraq	http://musingsoniraq.blogspot.com/	Conflict/Iraq monitoring
Military advisor (Syria expert)	https://twitter.com/miladvisor	Conflict/Syria monitoring
LiveUapMap	https://syria.liveuamap.com/	Conflict/Syria monitoring
Peto Lucem	https://twitter.com/PetoLucem?ref_src=twsrc%5Egoogle%7Ctwca	Conflict/Syria monitoring
Le Carabiner	https://twitter.com/LCarabinier	Conflict/Syria monitoring
ArabianIntel	https://www.google.com/maps/d/u/0/viewer?ll=35.602811200000	Conflict/Syria monitoring
syriahr	http://www.syriahr.com/en/	Conflict/Syria monitoring
Institute for the study of the war	http://iswresearch.blogspot.com/	Conflict/Syria monitoring
Assistance Coordination Unit	https://www.acu-sy.org/en/#	Conflict/Syria monitoring
Suriyak	https://twitter.com/suriyakmaps?lang=en	Conflict/Syria monitoring
Syria Civil War Map	https://syriancivilwarmap.com/	Conflict/Syria monitoring
Humanitarianaccessteam.org	https://humanitarianaccessteam.org/user/login	Conflict/Syria monitoring
Agathocle de Syracuse	http://www.agathocledesyracuse.com/	Conflict/Syria monitoring
Global Energy Network Institute	http://www.geni.org/globalenergy/library/national_energy_grid/	Global Atlas/energy grid
Populationpyramid	https://www.populationpyramid.net	Global Atlas/population indicators
UN Population Division	http://www.un.org/en/development/desa/population/	Global Atlas/population indicators
Citypopulation	https://www.citypopulation.de/	Global Atlas/population indicators
World Bank	https://data.worldbank.org/indicator	Global Atlas/socio-economic indicators
The Global Economy	https://www.theglobaleconomy.com/index_api.php	Global Atlas/socio-economic indicators
International Monetary Fund	https://www.imf.org/external/pubs/ft/weo/2018/01/weodata/we	Global Atlas/socio-economic indicators
Knoema	https://knoema.com/	Global Atlas/socio-economic indicators
World Trade Organisation	https://www.wto.org/english/res_e/statis_e/natl_e.pdf	Global Atlas/socio-economic indicators
AQUASTAT	http://www.fao.org/nr/water/aquastat/data/query/index.html?la	Global Atlas/water and land resources
Humanitarian Data Exchange	https://data.humdata.org/	Humanitarian/DRR
Preventionweb	https://www.preventionweb.net/countries/pri/data/	Humanitarian/DRR
Reliefweb	https://reliefweb.int/	Humanitarian/DRR
HumanitarianResponse	https://www.humanitarianresponse.info/	Humanitarian/DRR
Reach-Initiative	www.reach-initiative.org/maps	Humanitarian/DRR
FarsNews	http://en.farsnews.com/	Media monitoring
Newsnow	http://www.newsnow.co.uk/h/?utm_source=newsnow&utm_cam	Media monitoring
Euronews	https://www.euronews.com/	Media monitoring
Reuters		Media monitoring
International Organisation for Migratic	http://migration.iom.int/europe/	Migration monitoring
EU HOME Affairs (borders)	http://ec.europa.eu/dgs/home-affairs/what-we-do/policies/bord	Migration monitoring
EU HOME Affairs (relocation)	http://ec.europa.eu/dgs/home-affairs/what-we-do/policies/euro	Migration monitoring
Cruscotto Statistico Giornaliero (Italy)	http://www.libertaciviliimmigrazione.dlci.interno.gov.it/it/docun	Migration monitoring
UNHCR	http://data.unhcr.org/mediterranean/regional.php	Migration monitoring
DTM_IOM	https://twitter.com/DTM_IOM	Migration monitoring
Eurostat	https://ec.europa.eu/eurostat/statistics-explained/index.php/As	Migration monitoring
Republic of Turkey- Ministry of Interio	http://www.goc.gov.tr/icerik/migration-statistics_915_1024	Migration monitoring
US Dept Defense	https://www.defense.gov/	National politics
Ministero de Politica Territorial y Func	http://www.seat.mpr.gob.es/portal/delegaciones_gobierno/dele	National politics

ANNEX 2. Example of maps by category.

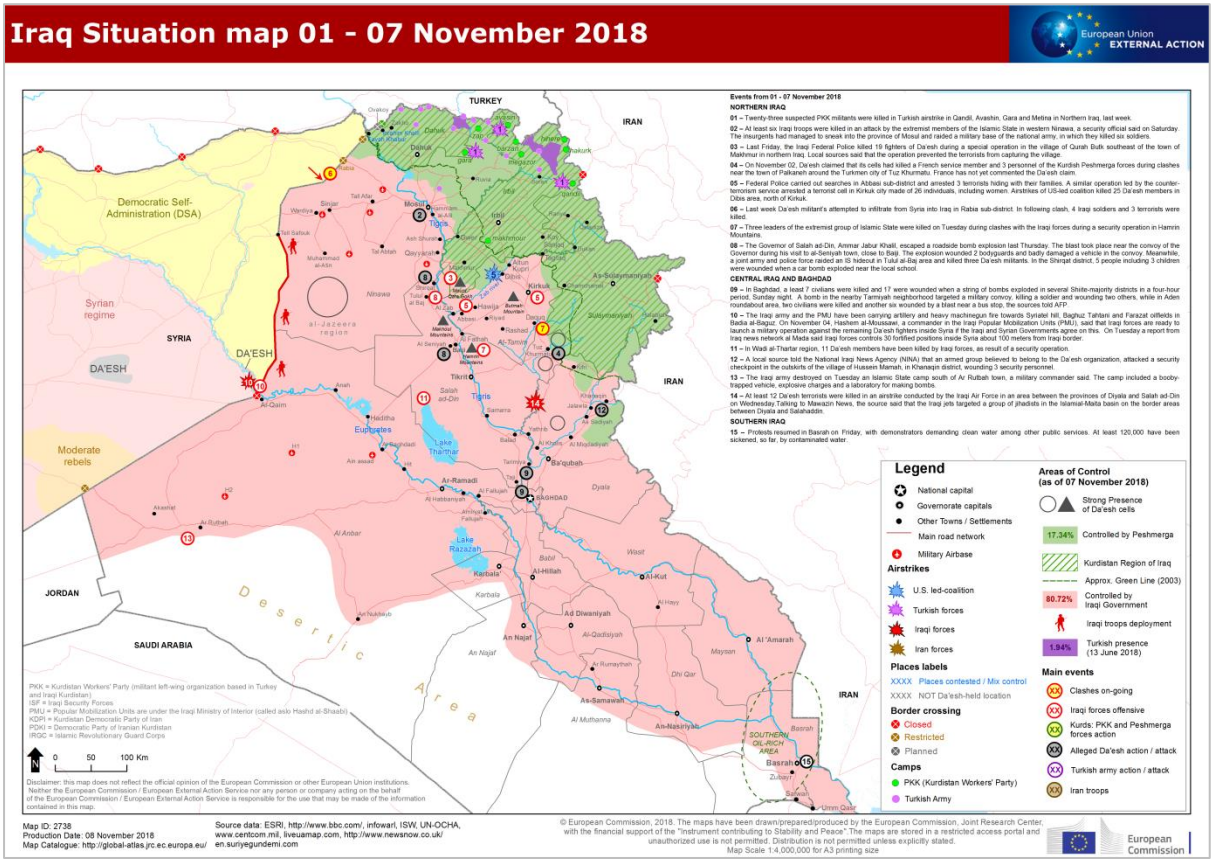
BASELINE MAP

The map shows the main dams (operational, proposed and under construction) in the Nile basin extent plus the contribution to Nile flow from White and Blue Nile, Atbarah, Bahr el Ghazal and Sobat rivers. This map has been requested by EEAS Situation Room as ad-hoc Red Product.



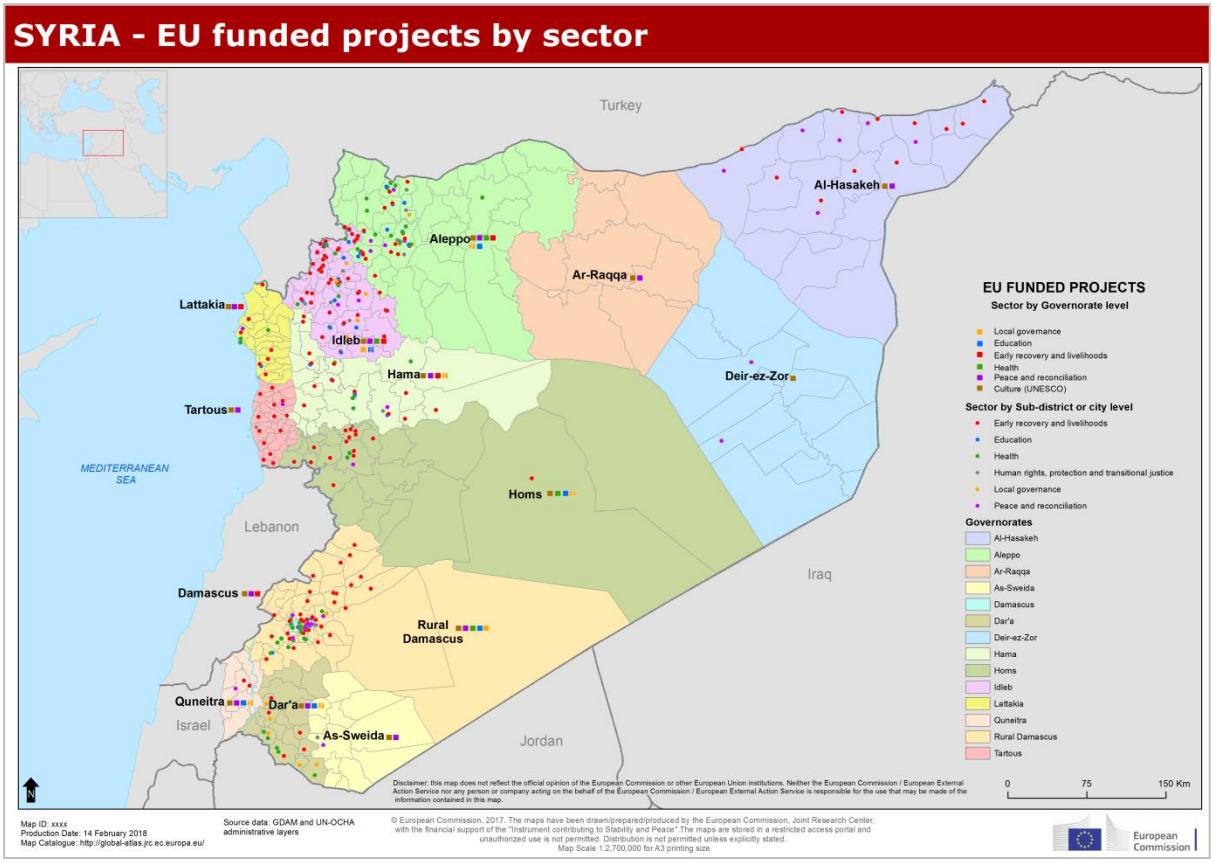
CONFLICT MAP

The map shows the controlled area in Iraq country and the main conflicts events for the monitored week. This map is updated every week and annexed to the Red Product, distributed by EU Situation Room of the EEAS.



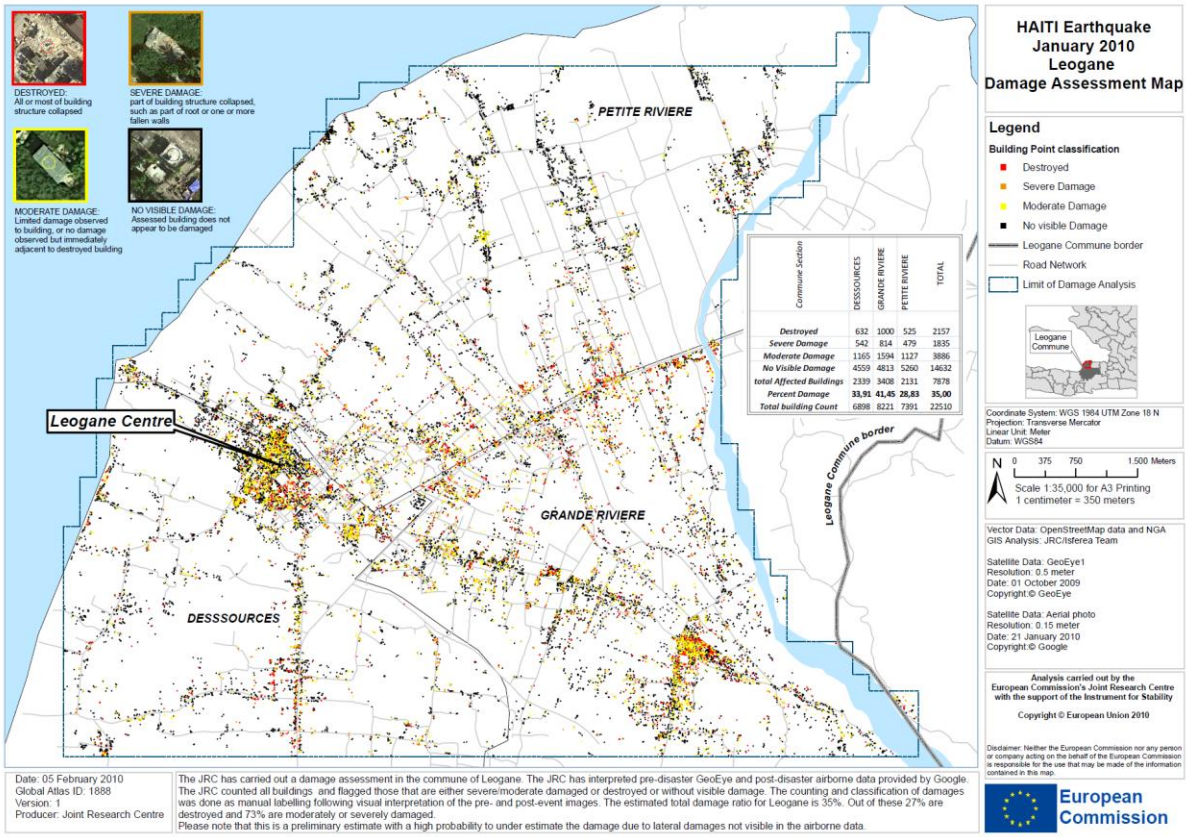
POLICY MAP

The map shows the distribution of the EU funded projects in Syria by sectors at Governorate, sub-district or city level. This kind of map is requested on-demand, in this case by the EU Delegation of Syria.



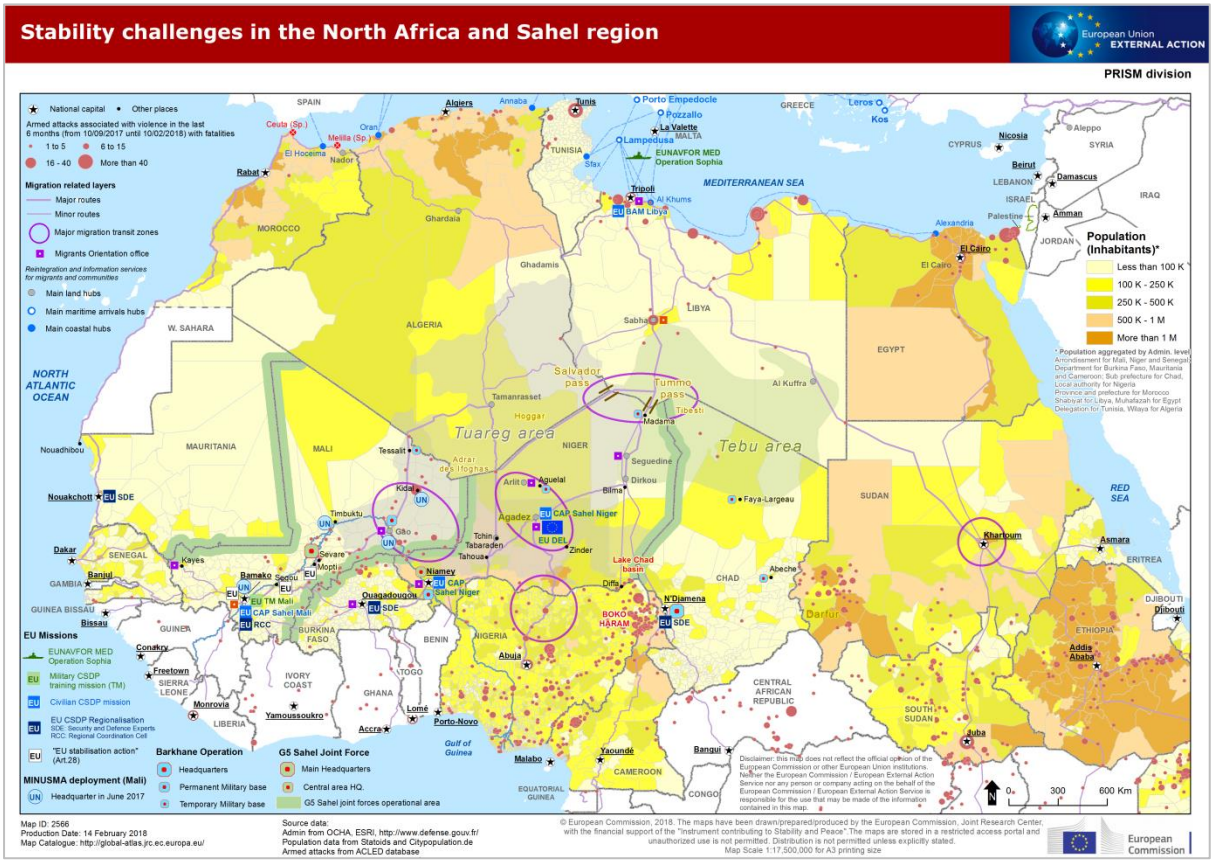
NATURAL HAZARD MAP

The map shows the detailed damage assessment carried out by JRC after the strong earthquake that hit Haiti in January 2010. The assessment covers the commune of Leogane.



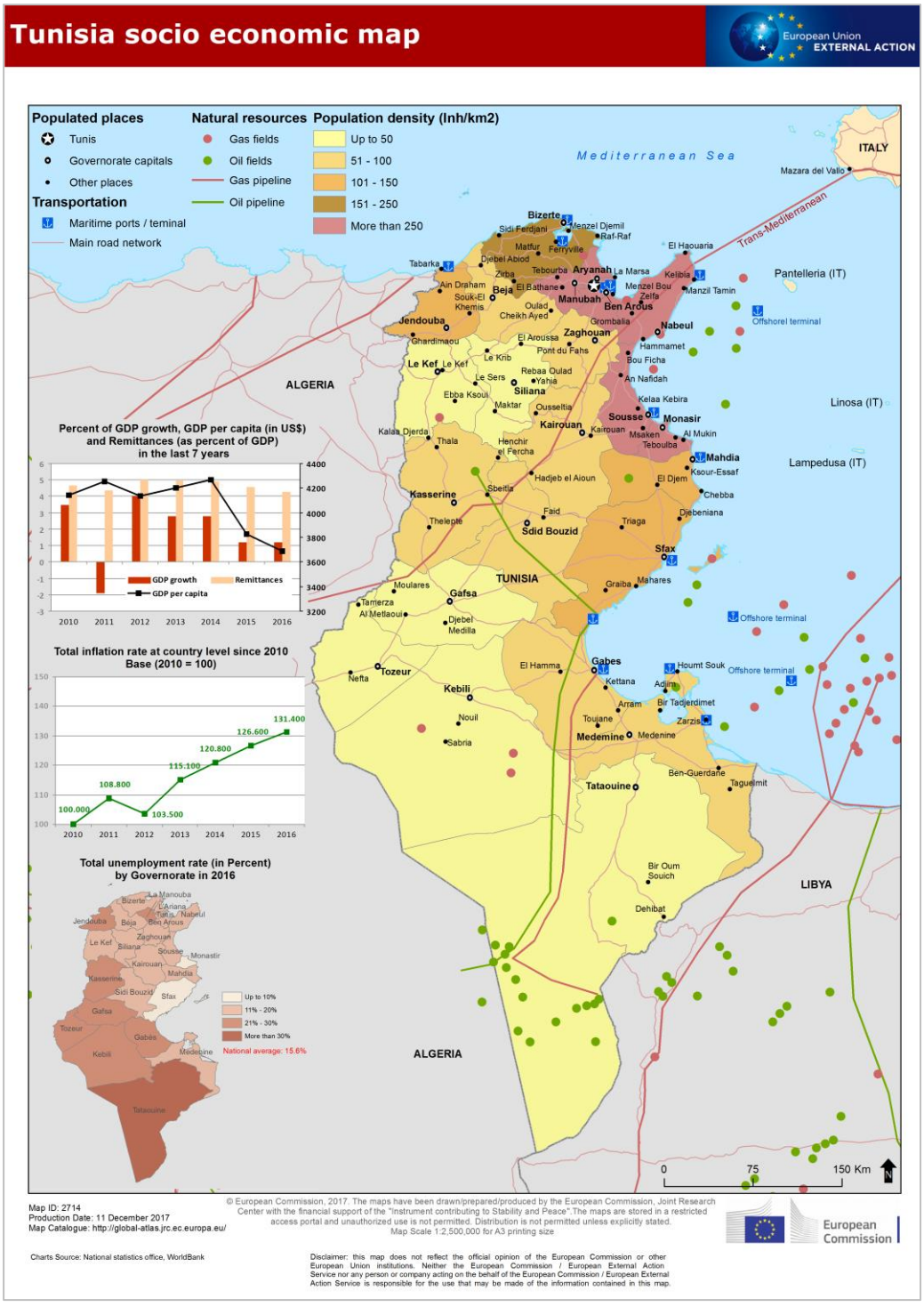
SECURITY THREATS MAP

The map displays key information to understand stability challenges and possible areas in need of EU intervention such as number of inhabitants at administrative level, migratory routes, migrants' transit areas, main conflicts in the region and location of EU mission. This map has been requested by PRISM (conflict Prevention, Peace building and Mediation) division of the CSDP and Crisis Response.



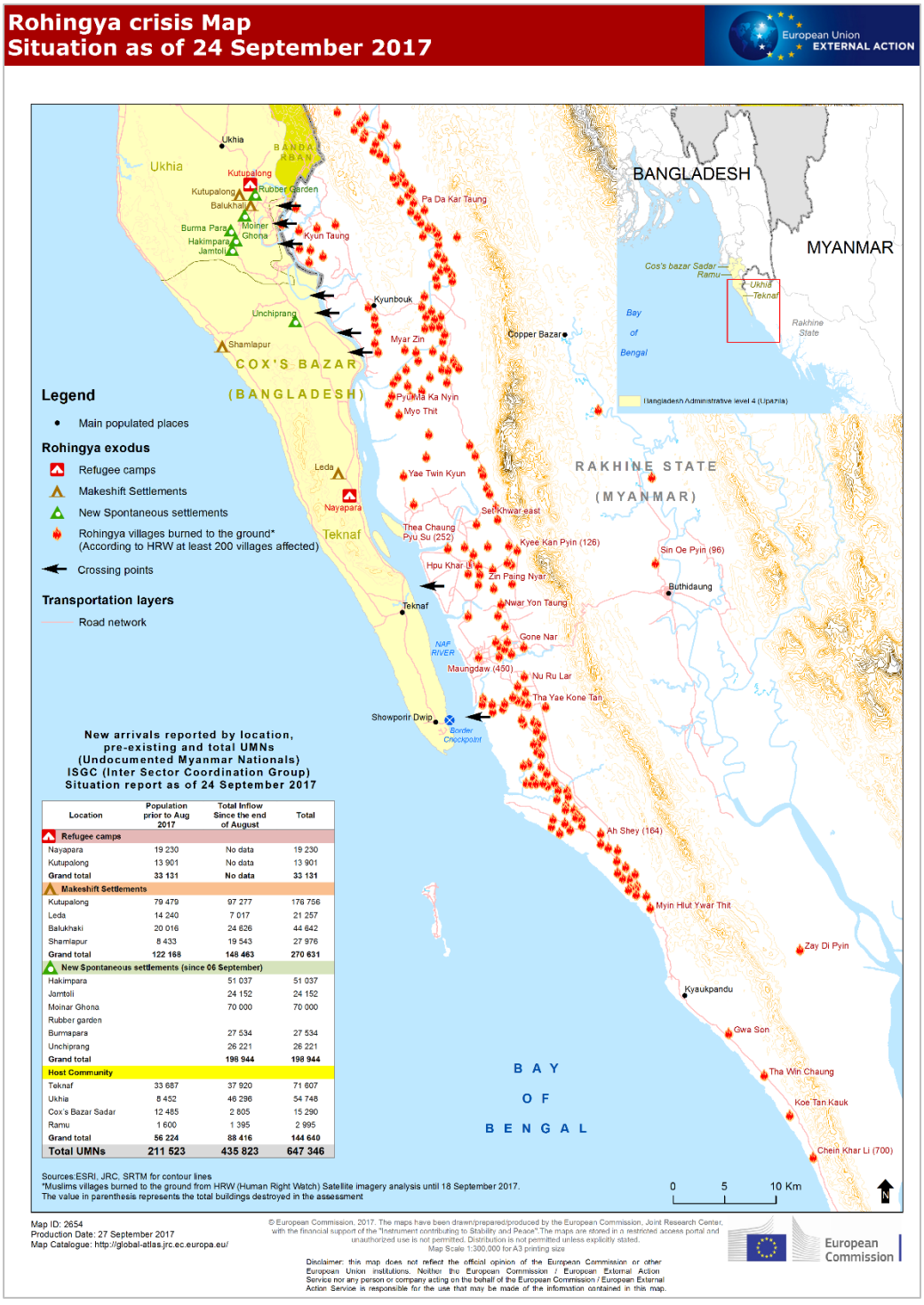
THEMATIC MAP

The map shows the socio-economic situation in Tunisia, as the percentage of GDP growth, GDP per capita and Remittances in the last 7 years. The total inflation rate at country level since 2010 and total unemployment rate at Governorate level are as well displayed. This map has been requested by EEAS Situation Room as ad-hoc Red Product.



MIGRANTS AND REFUGEE MAP

The map portrays key information about the Rohingya refugee crisis including location of villages burned out, new settlements and refugee camps. It also reports the trends of the exodus in Co'x Bazar district in Bangladesh. This map has been requested by EEAS Situation Room as ad-hoc Red Produced.



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